SCIENTIFIC AMERICAN SUPPLEMENT No. 735

Scientific American Supplement, Vol. XXIX. No. 735.
Scientific American, established 1845.

NEW YORK, FEBRUARY 1, 1890.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

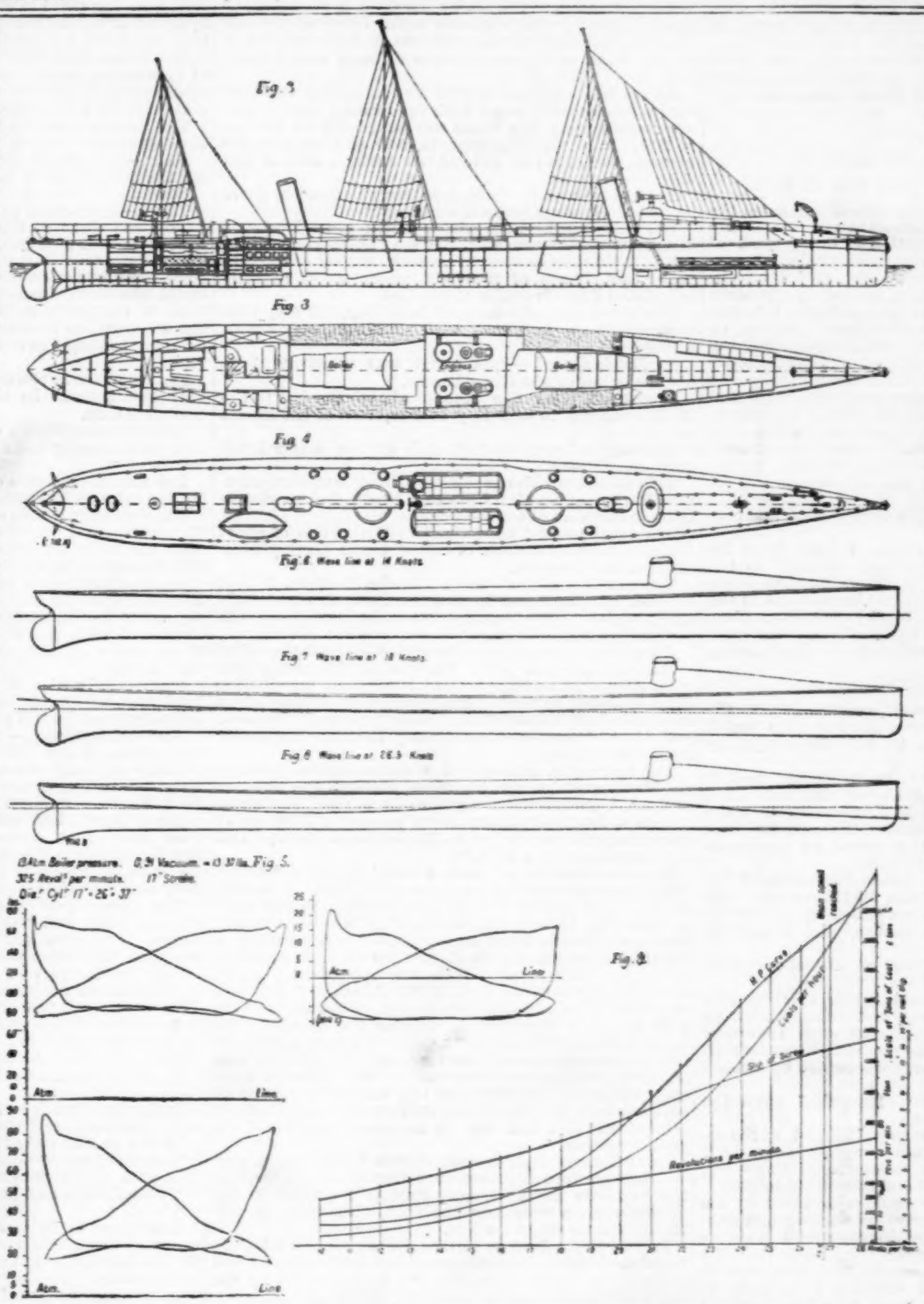
THE ITALIAN TORPEDO BOAT NIBBIO.

AMONG the oldest and certainly among the most successful of the Continental builders of torpedo boats must be classed Mr. F. Schichau, of Elbing, Prussia. Mr. Schichau has not been content simply to follow in the footsteps of the two leading English builders, but he has proved a most formidable rival; and, indeed, in some cases, it must be confessed, the English builders have followed the lead of the Elbing yard.

The remarkable speed attained by these vessels renders the data especially valuable.

The engravings represent one of five sister vessels built to the order of the Italian government. Their names are Aquila, Sparviero, Nibbio, Falko, and Avoltoio. The following particulars of these vessels have been supplied to us. They are 46·5 meters long (151 ft. 8 in.) and 5·2 meters wide (17 ft.). The draught of water is 2·3 meters (7 ft. 6 in.). The hull is divided into 12 water tight com partments, there being also longitudinal bulkheads. The vessel will continue afloat if all compartments forward of the boiler are filled with water.

Each vessel is fitted with two locomotive type marine boilers with 1,700 square feet of heating surface, and two sets of triple compound engines. The latter are placed amidships, while the boilers are placed fore and aft, the propeller shafts passing at the side of the after boiler. The cylinders are 17 in., 26 in. and 37 in. diameter by 17 in. stroke. The total horse power developed by the engines is set down at about 2,200 indicated; the boiler pressure is 13 atmospheres, and the air pressure in stokehold 30 mm. to 40 mm. (1·18 in. to 1·58 in.) The propellers are three bladed and of 1·8 meters diameter (5 ft. 11 in.) There are auxiliary engines for electric light, steam steering gear, and an air compressor for torpedo discharge for the bow tube, the tubes on deck ejecting their torpedoes by powder. The boiler and engines are entirely inclosed by the coal bunkers, as shown in our illustrations. There is also an electric signal apparatus. The three torpedo tubes are arranged as shown in the engraving, the complement of torpedoes carried being six. There are two Hotchkiss guns. The coal bunkers have a capacity of about 40 tons, with which these vessels can steam for a distance of 5,000 miles at 10 knots speed. All compartments have large bilge ejectors, which together can discharge 800 tons of water per hour. The displacement of the boats, fully equipped and with full bunkers, is 160 tons. The displacement during trial was 145 tons. The details of the trial displacement were as follows: Weight of boilers and engines, with water, etc., 61 tons; coals, 14 tons; torpedoes, munitions, 24 men, with equipment, spare gear, etc., 7·5 tons; weight of vessel, with torpedo guns and fittings, Hotchkiss guns, electric engines, signal apparatus, masts, sails, etc., 62·5 tons; total, 145 tons.



The trials of these boats were made in the Baltic, near Pillau, the course being defined by fixed landmarks placed 19 miles apart. Each boat ran at full power for three hours, and the following results are given:

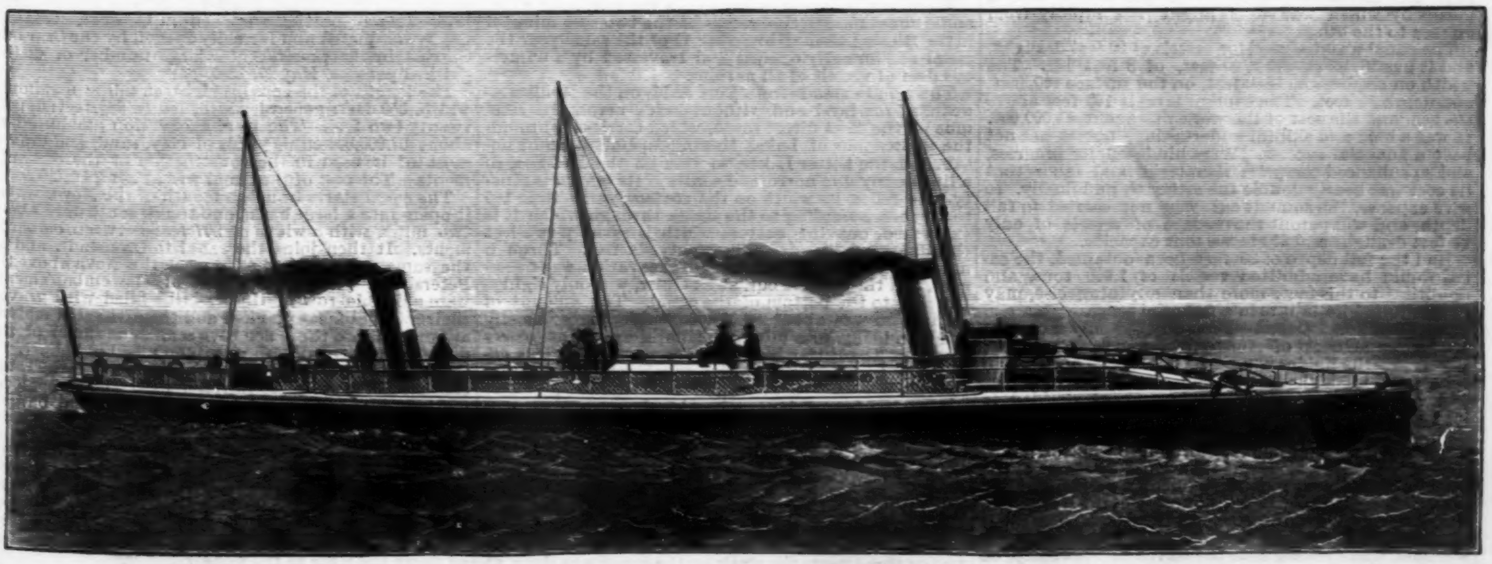
Aquila, tried July 28, 1888. Strength of wind, 4, with strong running sea; mean speed, 26·2 knots.

Sparviero, tried August 6, 1888. Wind, 3; mean speed, 26·6 knots.

Nibbio, tried August 22, 1888. Wind, 2; mean speed, 26·8 knots.

The horse power is said to have been about 2,000 indicated, and the engines worked without any hitch at an average speed of from 320 to 325 revolutions per minute. The boats are said to have turned in a circle of 300 meters by using the twin screws.

Referring to our illustrations, Fig. 1 is a general view of one of these vessels. Figs. 2, 3, and 4 are respectively a longitudinal section, a plan with deck removed and a deck plan of the same vessel. In Fig. 5 we give indicator diagrams taken from the engines of the Aquila, which well repay careful examination. The boiler pressure was 13 atmospheres and the vacuum 13·37 lb. The revolutions were 325 per minute. These diagrams must have been taken at full



THE NEW ITALIAN TORPEDO BOAT NIBBIO.

speed, as they work out very nearly the 2,200 indicated horse power given as the power required for full speed. Figs. 6, 7, and 8 show the wave line of the Aquila and sister vessels when running at 14, 18, and 26·5 knots speed respectively. In the diagram, Fig. 9, are given curves showing coal consumption, indicated horse power, slip of screw, and revolutions at speeds varying from 10 knots to 28 knots per hour.

The following details are given of five other boats built for the Italian navy, 39 meters long (128 ft.) and 4·8 meters wide (15 ft. 9 in.): Draught, 2·2 meters (7 ft. 2 in.); displacement, fully equipped, 85 tons; engines of triple-compound type, developing 1,200 indicated horse power. The contract speed was 21·5 knots during a three hours' run at sea. The actual speed obtained was 22·5 knots. We presume this was the best out of the five boats.

The ten boats made the passage from Elbing to Spezia, and encountered rough weather on the way. They all, however, arrived safely, making the run in short time. At the present time there are building at Elbing, besides some thirty other vessels, one twin-screw boat for the Russian government, with a guaranteed speed of 26½ knots, and five of the same type for other orders.—*Engineering.*

SHIP CANALS IN 1889.*

By R. E. PEARY, M. Am. Soc. C. E.

WHEN the idea of presenting something upon the subject of ship canals first occurred to me, it was my intention to give a brief description of every work of that kind, completed, in progress, and projected, giving its history, principal features, cost, actual or estimated, traffic, actual or expected, cost of maintenance and development, without, however, entering into any discussion of details, of merits of different routes, or of the question of canals *versus* railroads—something that would be of general interest and of a sufficiently non-technical character to be easily assimilated even in hot weather. But limited time and the unexpected extent of the task I had set before myself have hampered me until I feel that the result is hardly more than a ship canal directory. Still I have felt that even that might not be entirely without interest to many, and I trust that omissions and incompleteness will be regarded leniently.

Naturally the paper is simply a compilation and condensation.

For the material for condensation I have been indebted to Harcourt's "Rivers and Canals," to the annual reports of the chief of engineers, to various scientific and technical publications, the columns of the press, and, more perhaps than to any other one source, especially for the continuous record of the progress of the various projects, to the columns of *Engineering News.*

COMPLETED CANALS—ABROAD.

Languedoc Canal.—This canal, known also as the "Canal du Midi," is often spoken of as a ship canal, though its dimensions do not in any degree justify such a classification.

Its claim to the name seems to be in the fact that it was built for the use of the "ships" of that time (17th century) engaged in the coasting trade between the Atlantic and Mediterranean coasts of France, and that for its time it was undoubtedly as great an undertaking as the Suez canal in recent years.

It forms a communication between Bordeaux, on the Bay of Biscay, and Cette, on the Mediterranean. Its length is 140 miles, summit level 610 feet above the Mediterranean, depth 6 feet 7 inches, and it has 119 locks.

The canal was completed in 1681 at a cost of $7,200,000.

Caledonian Canal.—This canal is located through a remarkable valley called the Great Glen, stretching across the Highlands of Scotland, between Inverness Firth and Loch Eil, a distance of about 60 miles; 38 miles of this distance, however, are occupied by a chain of lakes.

In 1773 James Watt reported favorably upon the project, but nothing was done.

In the beginning of this century, Telford, at the request of the government, reported upon the project, and was intrusted with the execution of the work, which was commenced in 1804 and completed in 1823.

The government was led to build this canal by the expectation that it would save vessels a long and dangerous circuit by the Pentland Firth, where previous to the introduction of steam they were liable to be detained for weeks by contrary winds; and, also, that in time of war the canal would afford a convenient refuge for merchant vessels from privateers, and a means by which war vessels might pass rapidly from one sea to the other.

The canal was designed for vessels of 20 feet draught, and it has 28 locks 170 × 40 feet, of 8 feet lift. The width on the bottom is 50 feet, on the surface 120 feet, and depth 20 feet. The summit level is 100 feet above the sea, and the cost of the work was about $5,000,000. It was a bold and skillful undertaking, but it has not been a financial success. Wars hindered its progress, and so enhanced the price of material and labor that its cost was nearly double the estimate, and finally, to save expense, the summit cut was not carried to full depth, and will permit the passage of vessels of only 17 feet draught and 250 to 300 tons capacity.

Had the full depth of 20 feet been obtained, the canal would have admitted vessels of 1,000 tons, and doubtless to this fact, more than anything else, may be attributed its failure in a financial sense.

North Holland Canal.—Formerly the only means of access to the port of Amsterdam was by the Texel Roads and the Zuider Zee. The Zuider Zee abounds in shoals and its navigation is difficult, so early in the present century the Dutch government decided to make a new route for vessels trading with Amsterdam.

The shortest line from Amsterdam to the North Sea, in a westerly direction, was then considered out of the question, on account of the difficulty of maintaining an entrance on the exposed flat coast of the North Sea, and a northerly route through North Holland was adopted, starting from Lake Y, nearly opposite Amsterdam, and opening into the haven of Niewediep, on the Texel Roads.

* From the Transactions of the American Society of Civil Engineers.

The canal built on this route was known as the North Holland, and was commenced in 1819 and finished in 1825, at a cost of $5,000,000. It is 52 miles long, 123½ feet wide at the surface, 31 feet wide at the bottom, and 18½ feet deep. It has a double tide lock at each extremity, with chambers 237 × 51 feet and 82 × 18½ feet, and three regulating locks.

This canal was of great value to Amsterdam, and was of unusual magnitude for the time when it was constructed.

It is now superseded by the Amsterdam Ship Canal, and has lost its importance since the completion of the latter.

Crinan Canal.—This canal, across the peninsula of Kintyre, 9 miles long and 12 feet deep, enables vessels 160 tons to save a circuit of about 70 miles around the Mull of Kintyre.

Gloucester-Berkeley Canal.—The city of Gloucester has direct access to the sea by the river Severn and the Bristol Channel; but for some miles below Gloucester the course of the river is circuitous, and the rapid flow of the tides renders navigation difficult and dangerous.

An act was obtained in 1793 for connecting Gloucester by a direct ship canal with the estuary below, and after much delay this canal was completed by Telford in 1827. It is 16½ miles long, 13 to 20 feet wide at the bottom, 80 to 100 feet wide on the surface, and 18 feet deep.

At the lower end, where it enters the Severn, there is a tide lock to maintain a constant level.

Witham Canal.—This canal, which gives Boston a direct communication with the sea, available for vessels of 2,000 tons as compared with vessels of 300 tons previously, is one of the most important of recently completed English works of its class.

The canal is 3 miles long, 27 feet deep, 130 feet wide on the bottom, and cost, with some accessory works, $1,000,000.

St. Louis Canal.—This canal was constructed to avoid the bar of the River Rhone.

It extends from the Rhone above the bar to the Mediterranean in the Bay of For, east of the Rhone outlet.

It is 2 miles long, 206 feet wide at low water level, and 19½ feet deep.

Gota Canal.—This canal gives direct water communication across Sweden from the North Sea to Stockholm, a distance of some 300 miles.

The canal proper, however, is but a series of short links, connecting a chain of lakes which occupy four-fifths of the distance.

The canal is 46 feet wide on the bottom, 86 feet on the surface, and 10 feet deep, and is very solidly constructed. The summit level is 300 feet above the sea and there are 76 locks.

About 10,000 craft pass through the canal annually.

Suez Canal.—The main features of this canal, the most successful and important of all ship canals thus far completed, as well as the principal incidents of its inception and construction, are very generally known, yet a brief *resume* seems necessary to make the record complete to date.

The value of a channel of communication between the Mediterranean and Red Seas, through the Isthmus of Suez, is evident from a glance at a map, saving as it does a long, circuitous route around the Cape of Good Hope for maritime traffic between Europe and the southern coasts of Asia.

The construction of such a canal is not a modern idea, but originated in remote antiquity. It is said that a canal across the Isthmus existed in the time of Sesostris, 1600 B. C., which later was abandoned. Nero and Darius both contemplated constructing a canal here, and Harcourt states that there is evidence that a canal for small vessels was opened and maintained from about 600 B. C. to 800 A. D., but was subsequently allowed to fall into decay. Pope Sixtus V. is said to have thought of cutting the canal in 1585. Louis XIV., of France, had a proposition submitted to him to construct a canal, and Napoleon I. gave the project very serious consideration, but was deterred from carrying it into execution by the erroneous results of his engineers' surveys, these surveys showing that the level of the Red Sea was 10 meters above that of the Mediterranean.

In 1847 these figures were shown to be wrong, and accurate surveys demonstrated that the mean level of the two seas was the same, though the tides in the Mediterranean were only one foot, while those in the Red Sea were about six feet.

In 1854 M. De Lesseps obtained the concession for the canal, but much time was occupied in discussions and diplomatic negotiations, and the inauguration of the work did not take place until August 25, 1859.

Work really began in earnest in the following year, and August 15, 1869, the waters of the two seas mingled in the Bitter Lakes. November 17 of the same year the canal was formally opened and traversed by a numerous fleet of vessels of all nations.

The canal extends from Port Said, on the Mediterranean, at sea level and without locks, across the Isthmus by the most direct route, which carries it through the depressions of Lakes Menzallah, Ballah and Timsah, and the Bitter Lakes, to Suez on the Red Sea, in a line nearly due north and south. Its length is ninety-nine miles, its width on the surface varies from 196 to 328 feet, according to the strata through which it is excavated, but the bottom width is seventy-two feet throughout. The depth is twenty-six feet. Through a portion of the Bitter Lakes no excavation was necessary, and the deepest cut, at El Guisr, was only eighty-five feet to the bottom of the canal. The amount of excavation was about 98,000,000 cubic yards, mostly sand and clay, or a mixture of both, except at places south of the Bitter Lakes, where some rock was encountered. The cost of the canal was about $100,000,000.

A harbor formed by two breakwaters was constructed at Port Said, to maintain the channel dredged from the entrance of the canal to deep water of the Mediterranean.

These breakwaters are 4,600 feet apart at the shore ends, and 2,300 feet apart at the end of the eastern breakwater, which is 6,300 feet long, while the western one extends 3,500 feet farther, to deflect the silt-laden littoral current from the entrance. During the first two or three years the work on the canal was done almost entirely by forced Egyptian labor, as many as 30,000 men being employed at a time. In later years the work was done almost exclusively by machinery. From the day the Suez Canal was opened, its business increased steadily and rapidly up to 1877, when it amounted to 1,663 vessels annually. In the two following years the traffic decreased, owing to a general depression in trade, then it went up with a jump, more than doubling in amount from 1879 to 1882, and rapidly grew through 1883, when it amounted to 3,307 vessels of a net tonnage of 5,775,861 tons.

With this amount of traffic it became apparent that the capacity of the canal with its original dimensions, and only fourteen *gares* or turnouts, was practically reached, and it was evident that speedy and ample measures must be taken to increase its capacity.

Two projects were discussed—one to build a second canal alongside the original one, another to widen and deepen the present canal,

The latter project was approved in the beginning of 1885, and the canal is to be enlarged to a depth of 29·5 feet, and a width twenty-six feet below the surface of from 213 to 246 feet on tangents, and 246 to 262 feet on curves of less than 8,200 feet radius. The total amount of excavation requisite to complete this enlargement is estimated at 91,000,000 cubic yards, and the estimated cost is about $41,000,000.

The enlargement, however, is to be carried out in three successive stages.

First.—Deepening the canal to 27·8 feet and increasing the bottom width to 121 feet.

Second.—Widening to the final dimensions.

Third.—Deepening to the final dimensions.

The first stage of this work, to give a depth of 27·8 feet, is now in progress, estimated cost about $12,000,000, and pending its completion the traffic of the canal since 1883 has increased more slowly, although the canal has been opened to night traffic, reducing the time of transit from thirty-six to sixteen hours, and the increase has been more in the way of an increased average tonnage per vessel than in the number of vessels.

This increase in the average tonnage of the vessels is very instructive. In 1870 it was 1,000 tons, in 1888 it was 2,743 tons.

With the completion of the enlargement, the traffic will undoubtedly take another vigorous bound upward.

The financial success of the canal can be best judged by the value of its shares.

The ordinary shares drew dividends in 1886 of over 11 per cent. and preferred shares nearly 17 per cent. A year ago ordinary shares of $100 sold in London at $427.50 and in Paris at $434.

Commercially this canal is of more importance to England than to any other nation, as it shortens the voyage to her Indian possessions about 7,000 miles as compared with the voyage around the Cape of Good Hope, and about 75 per cent. of the traffic of the canal is English.

Strategically also it is of vital importance to England, and, as events have already shown, in case of complications she will possess and hold it at all hazards.

Amsterdam Canal.—This canal, which the circuitous route through the North Holland Canal, and the increasing size and draught of the vessels trading to Amsterdam, forced that city to construct, in order to hold its own against the more favorably situated ports of Rotterdam and Antwerp, extends due west from Amsterdam across the peninsula of Holland to the North Sea, a distance of fifteen and a half miles. Its bottom width is 88½ feet, its surface width 187 feet, and its depth twenty-three feet.

The greater portion of it was constructed through a shallow lake, and the remainder through low sand dunes. The principal difficulties in its construction were the formation and maintenance of the entrance on the North Sea, and the complete rearrangement of the system of drainage of the region traversed by it. This drainage is now pumped into the canal.

At the North Sea end there is, as on the North Holland Canal, a double lock, with chambers 390×60 feet and 227×40 feet. At the Zuider Zee end there is a triple lock, with one chamber 315×60 feet and two chambers 238×47 feet.

In the construction of the canal and harbor 21,000,000 cubic yards of sand were removed by dredging, much of it at a cost of only twopence per yard.

The canal was commenced in 1865 and completed in 1876, at a total cost of nearly $15,000,000.

Two railways and one road cross the canal on swing bridges.

The canal is doing a large and increasing traffic, as many as seven hundred vessels having passed through its double locks in one day, to the great benefit of Amsterdam.

St. Petersburg Canal.—The plans for this canal were matured in 1872–73, but work was not commenced until 1878. It was partially opened in October, 1884, and finally completed and formally opened by the Czar and Czarina in the presence of a large number of distinguished persons, May 27, 1885.

The length of the canal is eighteen miles; maximum width, 350 feet; general width, 180 to 240 feet; depth, twenty-two feet. The total excavation amounted to about 63,000,000 cubic yards of clay, sand, and gravel, most of it used in the construction of the embankments. The cost of the canal was about $9,000,000.

The canal starts from the mouth of the Neva, where it opens into a large basin, and trends southward about two miles, with a width of 207 feet between embankments. It then joins the canal to Cronstadt, and at the same point branches to meet the Neva above St. Petersburg. The foundations of the embankments were a double row of timber cribs filled with gravel, their internal faces planked and the excavated material pumped into the space between. The slopes of the dikes are protected with riprap on a bed of ballast.

The *personnel* and plant employed upon the canal consisted of 3,500 men, thirteen dredgers, three locomotives, with 230 cars, eighty-six lighters and barges, twelve tugs and seven stationary engines.

The canal has both strategical and commercial importance, opening up as it does communication for war ships and large vessels of all kinds directly with St. Petersburg. Previous to the construction of the canal, the cargoes of all vessels drawing over nine feet had to be lightered twenty miles up the river to St. Petersburg, and all goods for export had to be lightered down the river in the same manner.

The effect of this canal was to increase the exports of St. Petersburg from 280,000 tons in 1883 to 950,000

tons in 1886, but it was at the expense of Cronstadt, the commerce of which was practically destroyed.

Ghent-Terneuzen Canal.—Beginning as far back as 1251, several canals have been constructed to maintain the communication of Ghent with the sea, the last one being completed in 1827.

The distance from Ghent to Terneuzen by this canal was only twenty-one miles, as compared with 105 miles by the River Scheldt.

It, however, proved inadequate for the constantly increasing size of vessels since its construction, and it has recently been straightened and enlarged to a bottom width of 56 feet, a surface width of 173 feet, and a depth of from 20 to 22 feet, with most beneficial results to the city of Ghent.

COMPLETED CANALS—AT HOME.

Welland Canal.—The history of this canal is similar to that of St. Mary's, though on a smaller scale.

It was begun in 1824 and finished in 1833, by private parties, the depth being 8 feet.

In 1841 it was assumed by the Canadian government, and its enlargement to 9 feet commenced. The depth was afterward increased to 10 feet by raising the embankments, and the locks enlarged to correspond.

In 1867 the canal was capable of passing a 400 ton vessel, and it had cost up to that time about $7,500,000.

In 1871 it was found that it would be necessary to again increase its capacity, and the work of enlargement was commenced soon after, and completed in 1887.

It was intended at first that this enlargement should consist of an increase in the size of the locks to 270×45 feet, and an increase in the depth of the canal to 12 feet; but almost as soon as the work was commenced it was found that this would not be sufficient, and the depth was increased to 14 feet.

The estimated cost of this enlargement was between $12,000,000 and $13,000,000; the actual cost was considerably in excess of that sum.

The canal is 27 miles long, and extends from Lake Erie to Lake Ontario, parallel with and west of the Niagara River. Its depth as above is now 14 feet, and its bottom width 100 feet. It has 27 locks, with a total lift of 330 feet, and will pass vessels of 1,000 tons.

A further enlargement is very likely to be undertaken in the not far distant future.

St. Mary's Canal.—This canal, which forms the outlet of Lake Superior, is unique in several respects.

It is 1 mile long and has at present a depth of 16 feet. It contains the largest lock in the world, 515 feet long, 80 feet wide in the chamber, 60 feet wide at the gates, 17 feet of water on the sills and a lift of 18 feet.

The canal was originally constructed in 1855, and there were two locks 350×70 feet, with 12 feet of water on the sills, and 9 feet lift each. About 1870 it became evident that the capacity of the canal had been nearly reached, and the work of enlargement was undertaken.

This work consisted of the construction of the present lock and the deepening of the canal 16 feet.

These improvements were completed in 1881 at a cost of about $2,500,000, with a most astonishing result upon the traffic of the canal.

The number of vessels increased and their size and draught increased to correspond with the increased waterway. The tonnage of the canal increased from 1¾ million tons in 1881, the first year of the enlarged canal, to 4½ million tons in 1886—*i. e.*, it trebled in five years.

In 1888 the tonnage was over 5½ million tons.* From 1885 to 1886 the total tonnage increased 37 per cent., and from 1887 to 1888 the average tonnage per vessel increased some 20 per cent., the average now being about 657 tons.

The annual tonnage of the canal is now nearly as great as that of Suez—1,685 vessels have passed through the canal in one month.

In 1886 it was seen that the ultimate capacity of the canal would be reached in two or three years—that capacity being 96 vessels per day of twenty-four hours, and 84 having already passed in that time; and a still further enlargement was proposed, and is now in progress. This will consist of a lock 800×100 feet, with a depth of 21 feet on the sills and a lift of 18 feet, and the deepening of the canal to 20 feet.

The new lock is to be placed upon the site of the two old ones, and will be used in connection with the present new one. The cost of the enlargement is estimated at $4,738,865, and the time for its execution five years.

If, on the completion of this enlargement, the traffic of the canal takes such an upward bound as it did after the last enlargement—and there is no room to doubt that it will—Suez, even with its own enlargement completed, will have difficult work to keep pace with it.

The present lock in this canal is undoubtedly the finest, as it is the largest, in the world. It is manipulated entirely by hydraulic power furnished by the fall at the lock, and the operation of hauling in, locking and hauling out a vessel is easily accomplished in thirteen minutes. The cost per ton of passing vessels through the canal in 1882 and 1883 was one and a half to two cents; it is now about one-half cent.

Des Moines Canal.—This canal gives a passage around the Des Moines Rapids of the Mississippi River. Its length is 7·6 miles; width, 300 feet; depth at extreme low water, 5 feet, and at high water, 16 to 26 feet. The locks in this canal are 350×80 feet. The total cost of the canal, about $4,500,000.

In 1885 about 1,000 vessels passed through this canal.

Louisville and Portland Canal.—This canal, around the falls of the Ohio, at Louisville, is similar to the Des Moines canal. In 1885, 5,000 vessels, of a total tonnage of 1,217,331 tons, passed the canal.

CANALS IN PROGRESS—ABROAD.

Corinth Canal.—This canal will cut the isthmus of the same name, uniting the waters of the Ægean Sea and the Gulf of Lepanto, and make an island of the Morea.

The Isthmus of Corinth is a narrow neck of land, with a least width of not more than 6 kilos. (3·78 miles), and a maximum elevation of about 80 meters (262·5 feet.) It is a plateau between two chains of mountains, Mt. Gueranicus on the north and Mt. Onicus on the south, about 3,000 and 2,088 feet high respectively.

The ancients, Periander, Tyrant of Corinth, in 628 B. C.; Demetrius Poliorcetes, one of the successors of Alexander the Great; Cæsar, and Caligula had all seen the commercial advantages and importance of a canal at this point, and Nero actually undertook the execution of the project, and the evidences of his work after the lapse of eighteen centuries are perfectly distinguishable, and show the measures of the human force that this emperor had at his command.

On the Ægean side there was a trench 70 meters (230 feet) wide at the highest part, 40 meters (131·3 feet) at the lowest, and about 200 meters (656 feet) long. The earth was banked up on both sides and the trench ends abruptly in a nearly vertical face.

On the Corinth side vestiges of Nero's work are also visible, and across the entire breadth of the Isthmus is a succession of pits 2 meters (6·56 feet) square, where soundings were made to a depth of 20 meters (65·6 feet).

There was a great demonstration at the inauguration of this work, and Nero turned the first sod with a golden spade, in approved modern style. He is said to have abandoned the project upon being informed by scientists that the sea was higher on one side of the Isthmus than on the other.

In 1881 a French company was organized with a capital of $6,000,000, M. De Lesseps being honorary president. Three routes were surveyed across the Isthmus, and the one finally selected was the same as the ancient one of Nero. The right of way and uncultivated land on both sides were given by the Greek government on condition of the work being completed without subsidy.

May 4, 1882, the work was inaugurated, the King of Greece turning the first sod with a silver spade and the queen firing a train of dynamite mines. The line of the canal is perfectly straight and its total length is 6,400 meters (4 miles). Its section as originally proposed was 22 meters (72·18 feet) wide on the bottom, and 8 meters (26·25 feet) deep at low water. The side slopes 1-10 in rock, 2-1 in sand, and 1-1 in firm earth, giving a water surface width of from 23·6 meters (77·43 feet) to 45 meters (147·64 feet). It was expected that the canal could be finished in four years, and a contracting firm took the job for $5,280,000, but inaccurate estimates as to the amount and quality of rock to be excavated, the necessity of flattening the side slopes and the corresponding increase of excavation have greatly prolonged the work and increased the expense.

The original contractors were obliged to throw up the work, and it is being completed by another firm. It is now expected that the canal will be completed in 1890 or 1891, and the total cost is variously estimated at from $9,000,000 to $12,000,000.

The completed canal will be 4 miles long, with a surface width of about 28 meters (91·87 (feet), a bottom width of 16 meters (52·42 feet), and a depth of 8·5 meters (27·89 feet). The depth of the cut at the highest part of the Isthmus will be 228 feet. The *personnel* and plant employed upon the canal has naturally varied with the progress of the work; but at its maximum has been about 3,000 men, 15 locomotives, 700 cars, 6 or 8 dredges, with their attendant tugs and barges. The maximum day's work has been 8,000 cubic meters (10,464 cubic yards). The total amount of excavation will be about 8,500,000 cubic meters (11,118,000 cubic yards), of which some 5,000,000 cubic meters (6,910,000 cubic yards) will be rock. Up to the end of last year something over 5,000,000 cubic meters (6,910,000 cubic yards) had been removed.

The work on this canal has been especially interesting from the various systems of attacking the great mass of excavation that have been successively tried.

Two roads and one railroad cross the canal at a height that will clear the masts of all vessels.

This canal will shorten the voyage of vessels going from the Adriatic Sea to Turkey and Asia Minor by 185 miles, and those coming through the Straits of Messina by 95 miles.

It is estimated that the annual tonnage making use of the canal will be 4,500,000 tons, and the tolls for vessels from the Adriatic will be twenty cents per ton, and those from the Mediterranean ten cents.

North Sea-Baltic or Holstein Canal.—Considering the auspices under which it is to be constructed, and the principal incentive to its inception, this canal will probably be the most commanding work of its kind in Europe.

The project for a ship canal between the Baltic and North Sea dates back about forty years. There are, however, three small canals in existence between the two seas, one of which—one of the oldest canals in Europe—is still in use, and was commenced in 1391 and completed in 1398.

Another was constructed in 1525, and the third, projected in 1571, was commenced in 1777, and completed by King Christian of Denmark in 1785. This latter has a depth of 10½ feet.

Prussia had given the subject of a ship canal serious consideration previous to 1866, but the war of that year gave the matter a quietus.

In 1878 the project was again brought forward in a vigorous manner, first by private parties, and then by the government, which gave the entire subject careful legislative consideration during 1881–83, and finally approved the bill in June, 1886.

June 3, 1887, the German Emperor officially inaugurated the canal, and only last month proposals for some 15,000,000 cubic yards of additional excavation were advertised for by the Imperial Commission at Kiel.

All the projects for this canal having originated in military and political considerations, the same considerations controlled the selection of the final route, from the important naval station of Kiel, on the Baltic, to Brunsbuttel, on the deep water at the mouth of the Elbe, from among some sixteen proposed locations.

From the Elbe the canal passes through swampy land, and then through gradually rising ground, to the "divide" eighty-two feet above the sea.

Thence to the Eider, a portion of which is utilized, thence to the Eider Lakes, and thence *via* the Eider Canal, rectified and enlarged, to Holtenau, near Kiel.

The length of the canal will be between sixty and sixty-one miles, the usual radii of curves 4,900 and 6,500 feet, with a minimum of 3,275 feet.

The chief value of the canal being in the speed with which it can be traversed, the curves will be as easy and few as possible. The average cross section of the canal will be 85 feet 3 inches wide at bottom, 197 feet at water surface, and 27 feet 10½ inches deep, giving 3,930 square feet of prism, which will permit the ordinary Baltic vessels to pass without trouble. The lakes and special sidings will accommodate war vessels. The depth will possibly be increased to 29 feet 6 inches, and the future enlargement of the canal is provided for by the purchase of a strip of land along the south side of the canal.

The canal is a thorough cut, with tidal locks at each end. The mean range of tides in the Baltic is about 1 foot 8 inches above and below the canal level, and in the Elbe 4 feet 6 inches above the same level.

At Brunsbuttel there will be three locks, viz., one 275×41 feet, one 412×82 feet, and one 1,180×196 feet, and at the Baltic end one large one; this latter, however, will be usually open. The locks will be of massive construction, worked by hydraulic power.

Four railroads and several highways will cross the canal on drawbridges.

The total amount of excavation is 67,000,000 cubic yards, and the estimated cost of the canal is $39,000,000. Of this sum $12,500,000 represents the excess cost of the work as a military canal over what it would cost for purely commercial uses. The estimated cost of maintenance is $450,000 to $500,000.

The commercial advantages of the canal are the saving in distance, time, pilot dues, and loss in going around Denmark. The saving in distance by vessels coming from the south and west of London to the Baltic is 237 miles, and from German ports some 425. The saving in time is from thirty hours for steamers to four days for sailing vessels. The greater safety is also an important item, two hundred vessels being annually lost in the dangerous passage from the North Sea to the Baltic.

The North Sea-Baltic traffic is variously estimated at from 36,670 to 40,000 vessels annually, with a registered tonnage of 12,240,000 tons, 5,500,000 to 9,000,000 tons of which would use the canal at a toll of 18¾ cents per registered ton.

The great charm of the canal, however, is its military importance, allowing the German fleet to be concentrated either in the North Sea or the Baltic with great rapidity.

Manchester Canal.—This canal, now in process of construction, will make the city of Manchester, at present fifty miles from the sea and thirty-five miles from the head of the tidal estuary of the Mersey, practically a seaport, and will completely alter the destination of an immense amount of tonnage now entered or cleared at London, Hull, and especially Liverpool.

It is said that the scheme for connecting Manchester with the sea dates back to 1712. In 1882 the matter was taken up vigorously by the local authorities and capitalists of Manchester. The first project considered was to deepen and widen the Irwell, so as to make a tidal waterway, a second Clyde, from the bar of the Mersey to the Manchester docks, a distance of fifty miles. Thorough surveys and studies led to the rejection of this project, and the adoption of the plan on which the canal is now being built, made by Mr. Williams, C. E.

From the outset great opposition was encountered from the Liverpool and Mersey interests, and from the several important railroad companies whose lines cross the line of the canal, and which would be put to large expense to modify their lines so as not to interfere with the navigation of the canal.

This opposition delayed the passage of the canal bill in Parliament for several years, and it was not until the summer of 1887 that this opposition was overcome and the bill finally passed. The capital of the company was immediately raised, and the contract for the construction of the canal given out the same year. Work was commenced at once, and is now being vigorously pushed, so that there seems to be no doubt but that the canal will be finished within the contract time of four years.

The length of the canal is a little over thirty-five miles from Manchester to the Mersey estuary, separated into two divisions:

First.—A tidal division from Eastham through the Mersey estuary to Runcorn, twelve miles, then inland eight miles further to Warrington, with a bottom width of 100 feet and a depth of 26 feet at low tide.

Second.—A canal division from Warrington to Manchester, fifteen and one-half miles long, with a bottom width of 100 feet, a depth of 26 feet, and a surface width of 300 feet.

There are four locks, or rather series of locks, these locks being built in groups of three of different sizes, and with intermediate gates, so that any size of vessel may be passed without waste of water. The total rise of the canal is sixty feet. The total amount of excavation is about 48,000,000 cubic yards, and the contract price for the work is $30,000,000.

The *personnel* and plant now engaged upon the canal is about as follows: Fifteen thousand men, 70 steam shovels, 50 steam cranes, 150 locomotives, 5,000 dump cars, etc., and an average of over 1,000,000 cubic yards per month are being taken out. The work on the canal seems to be a model of perfect organization and business-like procedure.

The figures of the expected traffic of the canal I am unable to give, but there seems to be no question that it will be a financial as well as an engineering success, there being a very dense manufacturing population within a radius of a few miles of Manchester, to which supplies must be brought and from which manufactured products must be taken away.

(*To be continued.*)

AMERICAN AND ENGLISH ENGINEERING.

As a contemporary says: There is an amicable rivalry between English and American engineers. The skill which they exhibit is the same, but its application differs in the two countries. Where American engineers have been compelled to build for the day or the morrow, English engineers have been able to build for the next generation and the century. But the extempore skill of the American engineer has, in turn, modified the massive conceptions of his English brethren, and English structures, such as the Forth bridge, are largely influenced by American ideas and

* For the year ending July, 1889, the tonnage was 6,932,208.

experience. The cantilever principle is borrowed from the United States, and is the product of American conditions of work and American fertility of invention and audacity of construction. Thus the genius and skill of each country supplements that of the other. The English borrow from America and the Americans borrow from the English, and both are better for the exchange.

THE FLIGHT OF BIRDS AND THE PROBLEM OF FLIGHT FOR MAN.

SINCE the time when it was told that the Athenian Dædalus and his son Icarus flew out of the Labyrinth, having put on wings, the spirit of man has never rested, as far as the problem of flight is concerned; but however wonderful the things he invented, he could never equal the bird. Although he could weaken the thunderbolt of Zeus, could succeed in producing lightning himself, and in making its velocity serve him—a velocity much greater than that of the bird—although he could raise himself above the earth by means of rarefied air or gases to such a height that even the bird could not follow, he could imitate the sunlight, could change winter into summer and summer into winter, still he has never been able to remove the disparity between the weight of his body and the air, which stands in the way of free flight; and there are not a few technologists who are of the opinion that all attempts in this direction will be wrecked on this crag. But there are believers, among whom Otto Lilienthal stands in the first rank. His work, entitled "Der Vogelflug als Grundlag der Fliegekunst" (The Flight of the Bird as the Basis of the Art of Flying), and recently published by the firm of R. Gaertner, in Berlin, is worthy of consideration. On account of its popular character it is well fitted to give even the untechnical an idea of the conditions required for flight and to excite argument on the subject. Taking the view that the question of flight can be treated otherwise than as a purely technical theme—since there are thinkers in all positions of life—and that there will always be some at work on the problem, he does not confine himself to a certain technical circle.

We cannot here examine this most interesting book very closely, but must limit ourselves to making a few short references and giving a few of the numerous illustrations. During a period of 23 years the author and his brother made many experiments, and came to the conclusion (as have others) that the real secret of a bird's flight lies in the arching of its wings, as shown in Figs. 1 and 2, which we reproduce. This accounts for the small amount of strength expended by a bird in flying forward, and also his power to adjust his wings so as to sail on the wind.

It is a subject for experiment to find whether the broad form of wing, like those of birds of prey and swamp birds (Fig. 3), with the articulated feathers, or the long and pointed wings, like those of the sea fowl (Fig. 4), will be the most advantageous.

The Lilienthal brothers used different apparatus in their experiments, two of which we show in Figs. 5 and 6. The second of these is for measuring the stroke of the wings. As the weight, G, sinks, the wings, F F, make a number of up and down strokes, the mechanical work of which can be measured.

The investigators constructed the first apparatus on the principle that the muscles of the legs, chiefly, must be used in producing the strokes of the wings by human power, the legs being moved alternately, and, as far as possible, so that the movement of each foot will cause a double stroke. After a little practice the experimenter succeeded in raising half of the entire weight. A person with the apparatus weighed 160 pounds, and in order to rise an 80 pound counter weight was necessary. The final conclusion drawn by the author is that the close imitation of the flight of birds in regard to the aero-dynamic conditions, etc., is the only way to obtain free and rapid flight, requiring but little power.—*Ueber Land und Meer.*

FIG. 1.

FIG. 2.

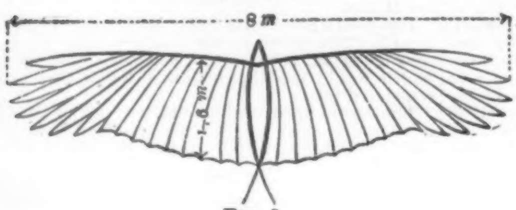


FIG. 3.

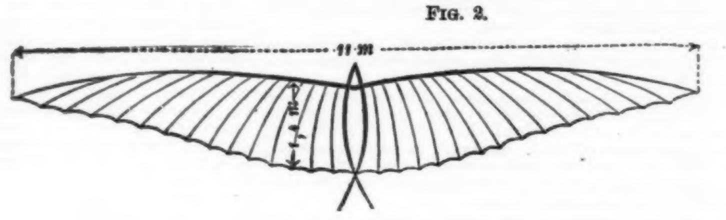


FIG. 4.

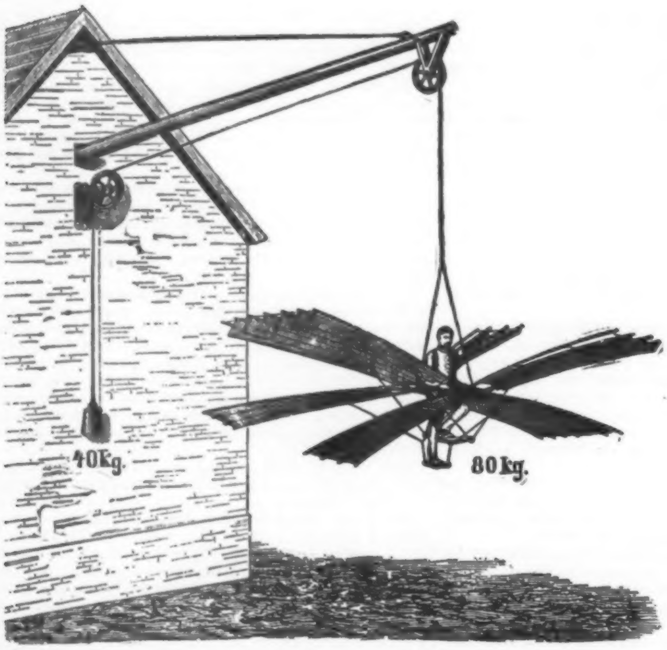


FIG. 5.

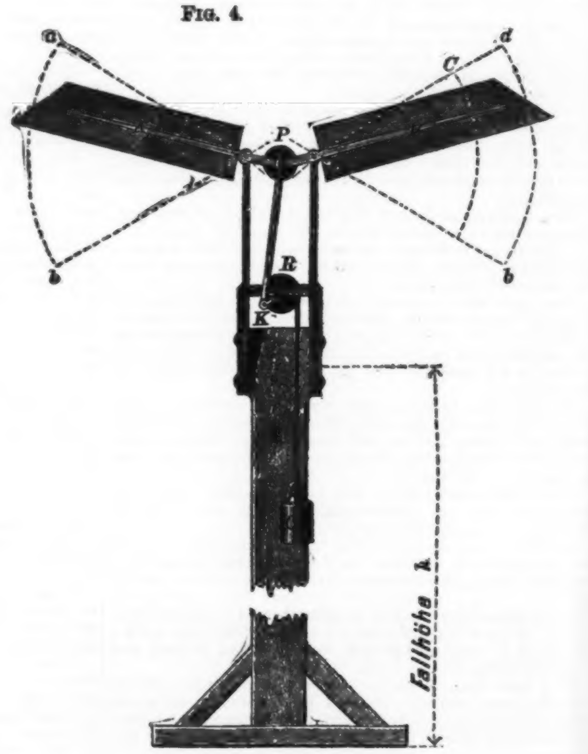


FIG. 6.

SOME EXPERIENCES WITH ZINC.

ZINC is often used in boilers and hot water tanks to prevent the corrosive action of the water on the metal of which the tank or boiler is composed. The action appears to be an electrical one, the iron being one pole of the battery, and the zinc being the other. Under the action of the current of electricity so produced, the water in the tank is slowly decomposed into its elements, oxygen and hydrogen. The hydrogen is deposited on the iron shell, where it remains. It will not unite with iron to form a new compound, but if any iron rust (known to the chemist as *oxide of iron*) is present, it will remove the oxygen from this and deposit the metallic iron on the plates. The oxygen of the water that is decomposed, instead of going to the iron, goes to the zinc, and forms oxide of zinc, and in the course of time the zinc will be found to be almost entirely converted into oxide, only a small fraction of the original metal being left.

On account of the action we have outlined above, it is generally believed that zinc is always a good thing to prevent corrosion, and that it cannot be harmful to the boiler or tank under any circumstances. Some of our experiences go to disprove this belief, and we have met with numerous cases in which zinc has not only been of no use, but has even been harmful. In one peculiarly marked case a one hundred horse power horizontal tubular boiler had been troubled with a deposit of scale consisting chiefly of organic matter and lime, and zinc was recommended as a preventive, some few weeks previous to our annual internal inspection. When the inspection was made, large amounts of detached scale from the shell and tubes were found in the bottom of the boiler, and the iron surfaces from which they had been detached showed markedly the action of the zinc, the crystals of which, deposited upon the iron, gave it the appearance of frosted silver work. On the rear portions of the tubes, the scale being much heavier and more obstinate to remove, partially remained; but it was easily loosened and detached, and when it was removed the same frosted appearance of the iron was observed. The beneficial action of the zinc was so obvious that its continued use was advised, with frequent opening of the boiler and cleaning out of detached scale until all the old scale should be removed and the boiler become clean. Eight or ten months later the water supply was changed, it being now obtained from another stream, supposed to be free from lime, and to contain only organic matter. This change of feed water was unknown to the inspector, who two or three months after its introduction opened the boiler for inspection, and was greatly surprised at its condition. The tubes and shell were coated with an obstinate adhesive scale, clinging tenaciously to the iron, and composed of zinc oxide and the organic matter or sediment of the water used. The deposit had become so heavy in places as to cause overheating and bulging of the plates over the fire. It was with difficulty that these patches were separated and removed by the use of long chisels made specially for the purpose. This action of zinc when the water supply is changed has been noted by us in many cases, but in no other case that we have yet met with has the contrast between its beneficial action at first and its injurious action afterward, in the same boiler, been so marked.

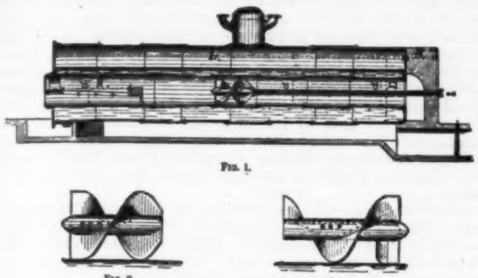
Another very interesting instance of the peculiar action of zinc under certain conditions came to our notice not long ago. This time the trouble was with a tank used for heating water, and containing coils of brass pipe through which exhaust steam was passed. The shell of the tank corroded rapidly, and one day a large crack opened in one of the plates, and the hot water (which was under a pressure of 75 pounds) was discharged into the room. An entirely new $\frac{5}{16}$ in. shell, 42 in. diameter and 8 ft. high, was then constructed, and when it was placed in position, a thirty pound pig of zinc was hung between the tubes to prevent the continuance of the corrosion. The zinc certainly did prevent the species of corrosion that had given so much trouble before, but it gave rise to a very peculiar alteration of the iron of which the new shell was made. After the lapse of two years, the handhole plates were renewed, and it was found that although the old ones had preserved their form, they were softened on their inner surfaces so that a penknife point could be easily thrust into them about $\frac{1}{16}$ of an inch. The metal on these surfaces was black and lusterless, and had every appearance of being graphite or blacklead. So soft was it that the strengthening ribs on one of the plates were entirely cut away by an ordinary pocket knife. The interior surface of the tank presented the same appearance, but as the tank showed no signs of distress, it was continued in use, and for six years it has proved serviceable and satisfactory, no leaks or other symptoms of weakness having been observed. The old handhole plates were kept for subsequent examination, but in a short time they hardened up so that a cold chisel would make scarcely any impression on them. The zinc pig that had been used was removed, and its character was found to be entirely changed. It had preserved its former shape and general outward appearance, but its fracture was no longer bright and metallic, resembling wood from which all the sap had been expelled. By carefully melting it in a clean black lead crucible, it was found that only fifteen per cent. of it remained in the metallic state. The remaining eighty-five per cent. was probably zinc oxide, though no analysis of it was made.

It appears from these experiences and from others of

like nature that the action of the zinc is not always as simple and harmless as it would appear to be at first thought. In fact, zinc is one of the numerous things that don't always work as we should naturally expect them to; and in making use of it, the boiler should be frequently opened and the action carefully watched, so that if any undesirable effects show themselves, they may be checked in time to prevent serious trouble.—*The Locomotive.*

SICKEL'S SMOKE CONSUMER.

Dr. Richard Sickel, of Germany, has devised an arrangement for preventing the formation of smoke and improving combustion in steam boiler tubes, which we illustrate. Fig. 1 of our engravings shows a longitudinal section of a steam boiler, the flue of which is fitted with Dr. Sickel's apparatus, Figs. 2 and 3 being two different forms of the apparatus. It consists of a hollow body placed in the flue, D, the shape of the body being somewhat similar to that of a sugar cone, the point being turned in the direction in which the gases of combustion pass. In the open rear end is an admission pipe, *d*, which is connected by a ring with the hollow body. This body is provided with small holes,



SICKEL'S SMOKE CONSUMER.

which enable the air introduced into the body to be discharged into the gases of combustion, and to be intimately mixed with them. This mixing is promoted by placing upon the hollow body helices, which cause the gases of combustion to pass through the flue in a helical line. The oxygen contained in the air admitted is designed to cause the combustion of the unburnt particles of the fuel carried away by the gases, and to convert into carbonic acid the carbonic oxide contained in the gases when the combustion is imperfect.

The action of the apparatus is as follows: The hollow body compels the gases of combustion to pass through an annular passage, and increases by the contraction of the free area of the flue the velocity of the gases of combustion so much that the soot is carried away through the flues, and oxygen is at the same time introduced through the small holes in the hollow body for the purpose of burning the solid particles contained in the gases of combustion which have not been completely oxidized. The helices increase the length of the passage for the gases of combustion within the flue, thus affording a better opportunity for giving off the heat generated to the substances to be heated, and cause the particles of carbon and soot, and the carbonic acid of the gases of combustion, to be mixed with the air introduced into the flue through the perforations, and promote in this manner the consumption of smoke and the production of fresh heat arising from combustion. The end of the admission pipe which is not connected with the hollow body terminates outside the flue in the open air. We are informed that according to official tests the saving in fuel effected by the application of Dr. Sickel's system is from 20 to 30 per cent.—*Iron.*

THE FILTERING OF WINES.

The labors of Mr. Pasteur have demonstrated that the alteration of fermented juices is due to the presence of special organisms that develop therein to the detriment of the constituent parts. Upon destroying these injurious ferments by heat (pasteurization), or by getting rid of them by perfect filtering, we succeed in making liquids proof against future fermentation.

The pasteurizing process applied to beer cannot be applied to wine without injuring its quality. So, Mr. Chamberland, director of Mr. Pasteur's laboratory, has sought a practical and simple method of eliminating ferments, and has devised what he calls a filtering bougie, an apparatus that meets all the exigences of installation and discharge perfectly, by reason of its form and the material of which it is made.

This apparatus, which is seen in section in Fig. 1, is a porcelain clay tube, B, which communicates through a rubber tube, *a*, with the transverse collector, C, and with a second rubber tube, D, with the general collector, *c*. The apparatus enters the liquid, as shown in the figure. In order to prime the filter, the air is sucked from the collector, and a circulation is thereby established. The liquid enters, through the pores, the interior of the "bougie," and leaves upon the exterior the dregs or ferments; then it passes into the collector, and from thence goes through a special conduit into rooms that have been previously sterilized by means of steam.

Fig. 2 shows the operation as a whole. The wine contained in the tuns descends through a pipe, F, and passes into a receptacle provided with a float valve which automatically regulates its admission, and from thence passes into an ordinary cloth filter. It is here freed from the sediment and other substances that would too soon choke up the bougies. A pipe, E, leads it to a receptacle, G, provided with a float that automatically regulates the level, which must always remain constant in the bougie tank, and be kept at the normal height indicated in Fig. 1.

From the receptacle, G, the wine flows through the pipe, Z, into the first bougie tank, which usually contains 500 filtering bougies. The wine is here filtered and is received by the transverse collectors, *c c*, which empty it into a general collector, *c'*. Thence it makes its exit through the cock, P, and traverses the glass tube, T, which shows whether or not the operation is going on satisfactorily, and finally, through special piping, is distributed among the sterilized rooms.

Through use, the bougies become choked up, and it is difficult for the liquid to enter them. It has therefore been necessary to arrange the filters so that they can be easily cleaned. The cleaning is effected as follows: The bougie tank is almost entirely emptied through a purge cock, then the collectors from which the bougies are suspended are separated from each other in succession. Then the bougies are scrubbed with a horsehair brush or a sponge. The dirty water at the bottom of the tank flows through a special tube, and the apparatus, after having been rerinsed, is ready to operate anew.

Wines thus treated are preserved indefinitely and are capable of undergoing a journey without alteration.—*Les Inventions Nouvelles.*

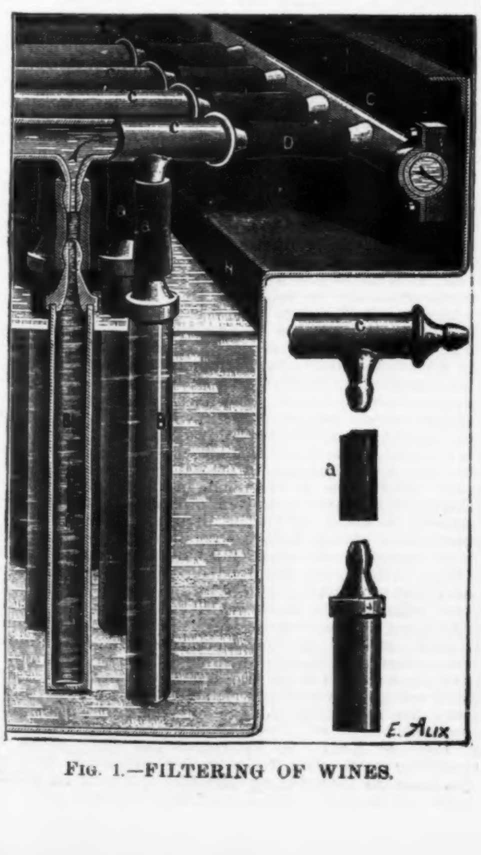


Fig. 1.—FILTERING OF WINES.

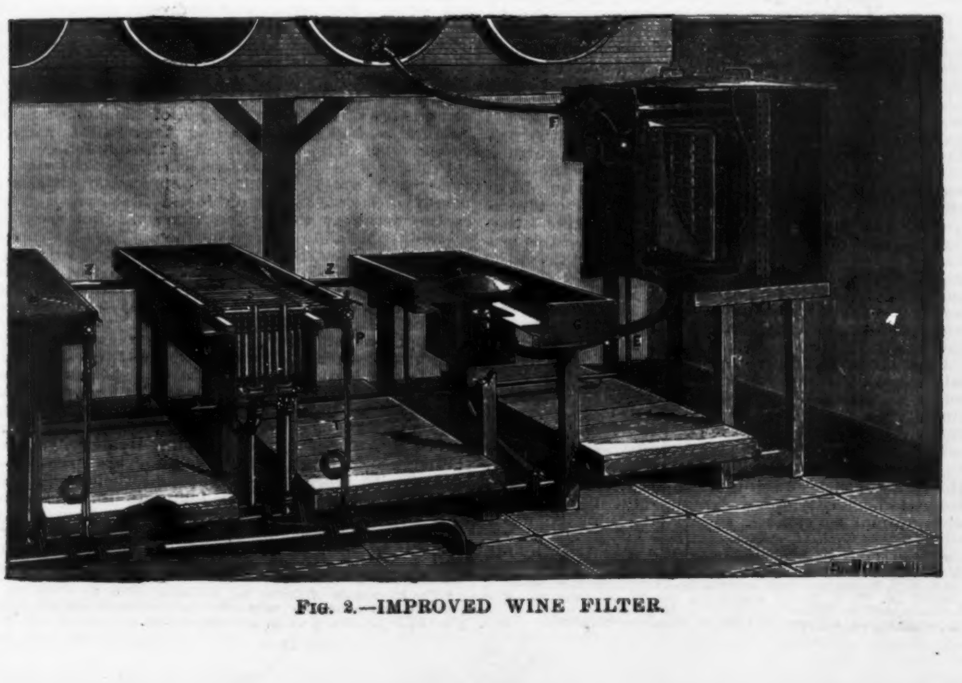


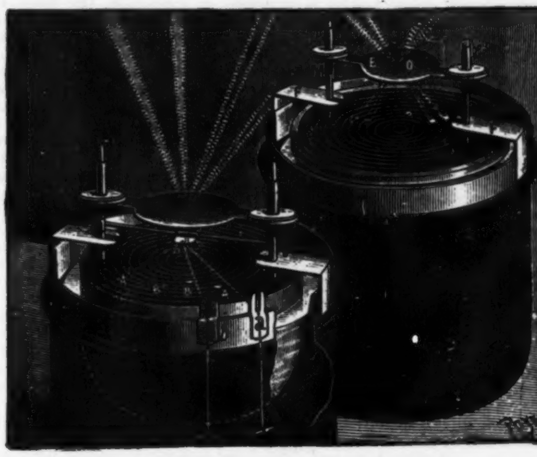
Fig. 2.—IMPROVED WINE FILTER.

GNOMON FOR DETERMINING THE TRUE TIME.

The instrument, wholly of metal, which is represented in the accompanying engravings serves, through two observations of the sun made respectively before and after midday, to determine the true time at a given moment of the day, and affords a means of regulating clocks and watches.

It consists essentially (see figure to the right) of a float designed to be placed in a vessel containing water. Perpendicular to its upper surface, which is provided with concentric circles, there are two uprights, M M, between which slides a screw containing a small aperture, *o*, in the center. The oscillations of the front are limited by the pieces, F F.

When the gnomon is exposed to the sun, we note, before and after noon, the hour indicated by the watch that is to be regulated, at the moment of the internal or external contacts of the luminous fascicle that has



DESRUISSEAUX'S GNOMON.

traversed the aperture, *o*, with one or more of the concentric circles. Half of the interval of time that elapses between two of the fascicle's contacts of the same kind with the same circle represents the true time. In order to have the mean time of such contact, it suffices to add to the result, or to subtract from it, the equation of the time for the day of the observation. All around the float there is a rim designed to receive the ballast that it would be necessary to add in order to render the upper surface of the float exactly horizontal.

Did we not wish to be obliged to level the instrument (which, however, is the most practical process), we might adopt the arrangement shown in the figure to the left. Here the two angular supports are connected by a rigid rod, *t*, from the center of which starts a thread that can be moved as a radius over the entire perimeter of the float and of the vessel containing the liquid.

Having described the apparatus, let us see how it is made to work. At the same time that we note the hour indicated by the watch to be regulated, at the moment of the contact of the luminous fascicle with one of the circles (A' or B', for example), we stretch the thread in the direction of the fascicle (an operation that is facilitated by the shadow cast by thread) after passing it through a slit in a small datum piece that is held in the hand. This piece is then placed astride the edge of the vessel. In the afternoon, when the fascicle is about to touch one of these same circles (B or A) again, we place the thread in the slit of the corresponding piece, *b* or *a*, and revolve the vessel from west to east until the shadow of the thread is seen projected upon the luminous fascicle, and then wait until the latter touches, in the same way that it did in the morning (internally or externally), the circle in question, so as to note the hour marked at the same instant by the watch.

Taking, as above said, half of the interval of time that has separated the morning and afternoon contacts, we shall have the hour, in true time, of the second contact.

The apparatus figured to the right represents the instrument just as it is constructed. It has appeared to us capable of rendering true service, and it is for that reason that we have thought it our duty to make it known.

The gnomon here described was devised by Mr. Hoarau Desruisseaux, who has studied the arrangement of it with much perseverance. The instrument is constructed by Mr. Molteni. It is an apparatus of very small size, and consequently very portable, and it may prove useful to travelers, who, in utilizing it, will renew methods analogous to those employed in antiquity.—*La Nature.*

[Continued from SUPPLEMENT, No. 734, page 11730.]

THE TEACHING OF SCIENCE.*

Problem VII.—To determine what happens when metals are heated with acids.—Iron, zinc, lead, tin, copper, and silver may be taken. On pouring diluted oil of vitriol on to iron or zinc, the metal dissolves with effervescence; the gas is collected, and when tested is found to burn. Thus a new gas is discovered, differing from all which have previously been studied, inasmuch as it is combustible; in order not to interrupt the study of the action of acids on metals, however, its further examination is postponed for a while. Resuming the experiments with metals, lead, tin, copper, and silver are found not to be acted upon by diluted oil of vitriol.

Muriatic acid, in like manner, dissolves iron and zinc and also tin with effervescence, and the gas which is given off in each case exhibits the same behavior as that obtained from iron or zinc and diluted oil of vitriol. Lead, copper, and silver are not appreciably affected.

Aquafortis is found to dissolve not only iron and zinc, but also copper, lead, and silver, and to convert tin into a white substance, to attack all the metals, in fact, thus justifying its name. The gas which is given off as the metal dissolves is observed to be colored; when it is collected over water, however, it is seen to be colorless, and to become colored on coming into contact with air; oxygen and nitrogen are, therefore, added to portions of the gas over water. In this manner, not only is a new gas discovered, but also a test for oxygen, and opportunity is afforded of here calling attention to the fact that air behaves exactly as oxygen, that the oxygen in air appears to be unaffected by its association with nitrogen—that, in fact, it is uncombined. From these experiments it is obvious that metals and acids interact in a variety of ways. Finally the dissolution of gold and platinum by aqua regia may be demonstrated.

Problem VIII.—To determine what happens when oxides are treated with acids.—In the course of the previous experiments a number of oxides have been prepared by burning various metals in air; these are found to be unchanged by water. The discovery that acids act on metals suggests a trial of the effect which acids will have on their oxides; so the oxides of zinc, iron, copper, and lead are submitted to the action of the three acids previously used. Sulphuric acid is found to dissolve zinc oxide, iron rust, and copper oxide, but no gas is evolved; excess of the oxide may be used, and the filtered liquid concentrated; the crystals which separate may be examined and compared with those obtained by dissolving the metal in sulphuric acid, etc. Litharge apparently is not changed by sulphuric acid, but red lead is, although not dissolved. Muriatic acid being used, all the oxides are found to dissolve, and in the case of red lead a greenish yellow gas is given off, possessing a most disagreeable smell; this is noted as a case for study. The product from the lead oxides is observed to crystallize out from the hot liquid on standing, so the undissolved original product is boiled up with water, and the solution is filtered, etc. Attention is thus directed to the difference in solubility of the products. Next aquafortis is used. Again all are dissolved, except the red lead, which, however, is obviously altered. In the case of the lead oxides the product is again less soluble than those afforded by the other oxides, but more soluble than the product obtained on using muriatic acid. The pupil has already been led to realize that of two substances capable of acting on a third, such as chalk gas and sulphur gas, which both combine with lime, one may be the stronger, and may turn out the other, sulphur gas turning out chalk gas from chalk. A comparison of the three acids with the object of ascertaining which is the strongest is therefore suggested. The metal or oxide is dissolved in one of the acids, and the others are then added. No positive result is obtained in case of zinc, iron, or copper, but the solution of lead in nitric acid is precipitated by muriatic and by sulphuric acid; the former precipitate is found to dissolve in boiling water and to crystallize out in exactly the same way as the substance obtained from lead oxide and muriatic acid. The sulphuric acid product is found to be almost insoluble in water, and also in muriatic and nitric acids: these observations make it possible, by examining the behavior toward muriatic and nitric acids of the products of the action of sulphuric acid on the lead oxides, to establish the fact that the product is the same whether lead be dissolved in nitric acid and sulphuric acid be then added or whether either of the oxides be treated with sulphuric acid. It is further evident that those acids that give difficultly soluble or insoluble products act with difficulty, if at all, on the metal. Other metals besides those mentioned may be now studied, and, a solvent being found, the acids which do not dissolve the metal may be added to the solution. In this way, for example, the chloride test for silver is discovered.

In experimenting with acids the pupils can hardly fail to stain their clothes and their fingers. The observation that acids alter colors serves to suggest experiments on the action of acids on colors, especially those of leaves and flowers. The use of litmus, methyl orange, cochineal, etc., may then be explained. As various oxides have been found to "neutralize" acids, the study of their effect on the colors altered by acids is suggested. Lastly, a few experiments with vegetable and animal substances, sugar, etc., may be made, which demonstrate the corrosive action of oil of vitriol and aquafortis.

Problem IX.—To determine what happens when the gas obtained by dissolving iron or zinc in sulphuric or muriatic acid is burnt.—The gas has been observed to burn with a smokeless, odorless flame. To ascertain whether, as in all other cases of combustion previously studied, the oxygen of the air is concerned in the combustion, a burning jet of the gas is plunged into a dry cylinder full of oxygen, in which it is not only seen to continue burning, but it is also noticed that drops of liquid condense on the cylinder above the flame; this immediately suggests that the product is a liquid. The jet is found to be extinguished in nitrogen. So evidently when the gas burns it forms an oxide. The experiment is repeated, and the gas burnt in a bell jar full of oxygen over water; the water rises as the combustion proceeds, proving that the oxygen is used up. To collect a sufficient quantity of the product for examination, the dried* gas is burned at a jet underneath a Florence flask through which a stream of cold water is allowed to circulate, the neck of the flask is passed through the neck of a bell jar, and the flask and bell jar are clamped up in an inclined position, so that the liquid which condenses may drop into a small beaker placed below the rim of the jar. What is the liquid? It looks very like water, and is without taste or smell. Is it water? How is this to be ascertained? What are the properties of water? The knowledge previously gained here becomes of importance. It has been observed that frozen water melts at 0° C., that water boils at 100°, and that one cubic centimeter weighs one gramme at 4° C.; so the liquid is frozen by the ice maker's mixture of ice and salt, a thermometer being plunged into it so that the solid ice forms on the bulb. The melting point is then observed. Subsequently the boiling point is determined, a little cotton wool being wrapped around the bulb of the thermometer. Lastly the density of the liquid may be determined. It is thus established that the gas yields water when burnt, and the name of the gas may now for the first time be mentioned and explained. The results thus obtained leave little doubt that water is an oxide of hydrogen, but in order to place this beyond doubt it is necessary to exclude nitrogen altogether. How is this to be done? Red lead is known to consist of lead and oxygen only, and readily parts with a portion at least of its oxygen. So dried oxygen is passed over red lead, which is then gently heated. Again a liquid is obtained which behaves as water. So there can be no doubt that water is an oxide of hydrogen. Water is not obtained on merely mixing oxygen and hydrogen. It is only produced when combustion takes place. To start the combustion a flame is applied to a small quantity of a mixture of the two gases; a violent explosion takes place. An opportunity is here again afforded of calling attention to the entire change in properties which takes place when the compound is formed. On heating red lead in hydrogen, lead is obtained, although on heating it alone it loses only a portion of its oxygen, and the "reduction" takes place very readily; evidently, therefore, hydrogen is a powerful agent. This observation suggests further experiments. Will it not be possible to remove oxygen by means of hydrogen from other oxides which are not altered on heating? and will not other combustible substances besides hydrogen remove oxygen from oxides?

Problem X.—To determine what happens when hydrogen and other combustible substances are heated with oxides.—Zinc oxide, iron rust, and copper oxide are now heated in a current of hydrogen. The first remains unaltered, the other two are seen to change, a liquid being formed which it cannot be doubted is water; the copper oxide evidently becomes reduced to copper. Is the iron rust similarly reduced to the metallic state? How is iron to be tested for? Iron is attracted by the magnet, and dissolves in diluted oil of vitriol with evolution of hydrogen. Applying these tests, no doubt remains that the iron rust is deprived of its oxygen.

Litharge and copper oxide may then be mixed with soot or finely powdered charcoal and heated in tubes; gas is given off which renders lime water turbid, and metallic lead or copper is obviously obtained. It is thus established that some but not all oxides may be deprived of their oxygen by means either of hydrogen or carbon. Opportunity is here afforded of explaining the manufacture of iron.

Several dried combustible organic substances, sugar, bread, and meat, may now be burnt with copper oxide in a tube the forepart of which is clean and is kept cool; liquid is seen to condense, while "chalk gas" is given off; the liquid has the appearance of water, and sufficient may easily be obtained to ascertain whether it is water. The presence of hydrogen in organic substances is thus discovered; its origin from water may now be explained, and the double function of water in the plant and animal economy may be referred to—viz. that it both enters into the composition of the animal and plant structure and also acts as a solvent. The combustion of ordinary coal gas, of alcohol, of petroleum, of oil and of candles, may then be studied, and the presence of hydrogen in all of these noted.

Problem XI.—To determine whether oxides such as water and chalk gas may be deprived of oxygen by means of metals.—It being found that hydrogen and carbon withdraw the oxygen from some but not from all metals, it follows that some metals have a stronger, others a weaker, hold upon or "affinity" to oxygen than has either hydrogen or carbon; the question arises whether any and which metals have so much greater an affinity to oxygen that they will withdraw it from hydrogen and carbon.

Copper and iron have been found to part with oxygen, but zinc and magnesium did not. So these four metals may be studied comparatively. Steam is passed through a red hot copper tube full of copper tacks; no change is observed. The experiment is repeated with an iron tube charged with bright iron nails; a gas is obtained which is soon recognized to be hydrogen, and on emptying out the nails they are found to be coated with black scale. Zinc and then magnesium are tried, and, like iron, are found to liberate hydrogen. Chalk gas is next passed over red hot copper, and is found to remain unchanged, but on passing it over red hot iron or zinc a gas is obtained which burns with a clear blue smokeless flame. This gas is not absorbed by milk of lime, but on combustion yields chalk gas. So it evidently contains carbon, and is a new combustible gas. Like hydrogen, it is found to afford an explosive mixture with oxygen. Finally, magnesium is heated in chalk gas. It is observed to burn, and the magnesium to become converted into a blackish substance unlike the white oxide formed on burning it in air. But it is to be expected that this oxide is produced, and to remove it, as it is known from previous experiments to be soluble in muriatic acid, this acid is added; a black residue is obtained. What is this? Is it not probable that it is carbon? If so, it will burn in oxygen, yielding chalk gas. So the experiment is made.

The experiments in which hydrogen is obtained from water and carbon from chalk gas afford the most complete "analytic" proof of the correctness of the conclusions previously arrived at regarding water and chalk gas, and which were based on "synthetic" evidence; taken together, they illustrate very clearly the two methods by which chemists determine composition.

As hydrogen and carbon form oxides from which oxygen may be removed by means of some metals, but not by all, the question arises, Which has the greater hold upon or affinity to oxygen—carbon or hydrogen? As it is the easiest experiment to perform, steam is passed over red hot charcoal; a combustible gas is obtained which yields water and chalk gas when burnt; so evidently the hydrogen is deprived of its oxygen, and this latter combines with the carbon, forming the combustible oxide of carbon. Will not carbon partly deprive chalk gas of its oxygen? The experiment is made, and it is found that it will. These results afford an opportunity of calling attention to and explaining the changes which go on in ordinary fires and in a furnace.

Problem XII.—To determine the composition of salt gas, and the manner in which it acts on metals and oxides.—It has previously been demonstrated that spirits of salt or muriatic acid is prepared by acting on salt with oil of vitriol and passing the gas which is given off into water. The solution has been found capable of dissolving various metals and oxides, chalk, lime, etc., and as water alone does not dissolve the substances, the effect is apparently attributable to the dissolved gas. So it becomes of interest to learn more of this gas in order that its action may be understood. It is first prepared, its extreme solubility in water is observed, and also the fact that as it dissolves much heat is given out; and it is noted that although colorless and transparent, it fumes in the air. How is its composition to be determined? Is there any clew which can be followed up? Reference is made to the previous observations, and it is noted that its solution dissolves various metals with evolution of hydrogen; water alone has no such effect. Is this hydrogen dissolved from the water or from the dissolved gas? The gas alone is passed over heated iron turnings, and the escaping gas is collected over water; it proves to be hydrogen. So evidently salt gas is a compound of hydrogen with something else. How is this something else to be separated from the hydrogen? Do not previous experiments suggest a method? Yes; they have proved that hydrogen has a marked affinity to oxygen, and now it is recollected that on treating muriatic acid with red lead—a substance rich in oxygen—a greenish yellow gas is obtained. The experiment is repeated on a larger scale, and the gas is examined. If it is contained together with hydrogen in salt gas, perhaps salt gas will be obtained on applying a flame to a mixture of the two gases, just as water is from a mixture of oxygen and hydrogen; the mixture is made and fired, and the result leaves little doubt that salt gas does not consist of hydrogen in combination with the greenish yellow gas—chlorine. Whence is this chlorine derived—from the salt or the sulphuric acid?

The notes are again consulted, and it is seen that a solution of silver in nitric acid gave a characteristic precipitate with muriatic acid but not with sulphuric, so salt solution is added to the silver solution, and a precisely similar precipitate is obtained, leaving little doubt that the chlorine is derived from the salt. It is now easily realized that the iron and zinc displace the hydrogen of the dissolved hydrogen chloride. What happens when the oxides are acted on? In addition to the metal they contain oxygen, which is known to combine readily with hydrogen, forming water; is water formed? Lime oxide is therefore heated in hydrogen chloride; a liquid is obtained which behaves exactly as a solution of hydrogen chloride in water. When the action is complete, after driving off all that is volatile, a solid remains very like fused common salt—doubtless zinc chloride, as it is to be supposed that as the hydrogen has taken the place of the zinc, the chlorine has taken the place of the oxygen. What, then, is the action of hydrogen chloride on chalk? It evidently not only separates the chalk gas from the lime, but also dissolves this latter. What is formed? Dry (unslaked) lime is therefore heated in a current of hydrogen chloride. It behaves just as zinc oxide, yielding a light product—evidently a solution of hydrogen chloride in water, as it dissolves zinc with evolution of hydrogen, and the residue is like that of zinc chloride. The important discovery is thus made that lime also is an oxide—that chalk, in fact, is a compound of two oxides; the resemblance of lime to zinc oxide and magnesium oxide is so striking that the conclusion is almost self-evident that the lime is probably a metallic oxide, and it may be here pointed out that this actually is the case. The gradual discovery of the composition of chalk in the manner indicated is an especially valuable illustration of chemical method, and serves to show how chemists are often obliged to pause in their discoveries and to await the discovery of new facts and methods of attack before they are able to completely solve many of the problems which are submitted to them. The solids obtained on dissolving zinc oxide and lime in muriatic acid and boiling down the solution, when all the water is driven off, are white solids like fused salt, but on exposure they gradually become liquid. In so doing they increase in weight, and evidently behave like sulphuric acid. Probably water is absorbed from the air: no change takes place when they are kept over sulphuric acid or dry lime. In this way two new desiccating agents are incidentally discovered.

Problem XIII.—To determine the composition of washing soda.—The study of this substance is of importance as introducing the conception of an alkali.

---

* Report of the committee, consisting of Prof. H. E. Armstrong, Prof. W. R. Dunstan (secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (chairman), Mr. W. A. Shenstone, Prof. Smithells, and Mr. Stallard, appointed for the purpose of inquiring into and reporting upon the present methods of teaching chemistry.—*Nature.*

* The importance of drying the gas is realized without difficulty, as previous observations have shown that the air is moist, and as the gas is given off in presence of water, lime may be used.

The preparation from salt is first described. On heating the crystals they melt and give off "steam;" the experiment is made in such a way that a quantity of the liquid is obtained sufficient to place beyond doubt that it is water. The water is found to be easily driven off on heating the crystals in the oven, and to constitute a very large proportion of the weight of the crystals. The conception of water of crystallization is thus gained. On heating the dried substance to full redness in the platinum dish, no loss occurs. The residue dissolves in water, and "soda crystals" may again be obtained from the solution, so that heat does not affect it. Perhaps acids which have been found to act so powerfully in other cases will afford some clew. On trial this is found to be the case: a colorless odorless gas is given off, which extinguishes a burning taper. Is this perhaps nitrogen or chalk gas? The lime water test at once decides that it is the latter. So it is determined that washing soda, like chalk, is a compound of chalk gas—but with what? With an oxide? The dried substance is heated in hydrogen chloride: chalk gas is given off as before, and a liquid which is soon recognized as water saturated with hydrogen chloride. The residue dissolves in water, and separates from the concentrated solution in crystals exactly like salt, and, in fact, is soon recognized to be salt; evidently, therefore, that which is present in salt along with chlorine is present in soda crystals along with oxygen, chalk gas, and water. The preparation of the metal sodium from soda is then explained. Acquaintance being thus made with compounds of chalk gas with two different oxides, the question arises, Which oxide has the greater affinity to the chalk gas? Will lime displace sodium oxide from soda or *vice versa*? On adding lime water to soda solution, a precipitate of chalk is formed. What does the solution contain? Lime water contains lime in combination with water; is the sodium oxide present in combination with water? Soda is boiled with milk of lime (in an iron saucepan to avoid breakage) until it no longer affects lime water; afterward the liquid is poured off and boiled down. The product is very unlike soda: it is very caustic, and when exposed to the air becomes liquid. If it is an analogous substance to slaked lime, it should combine with chalk gas and be reconverted into soda; this is found to be the case. Caustic soda is thus discovered. Chalk and lime are known to neutralize acids; both soda and caustic soda are found to do so, and their effect on vegetable colors is found to be the reverse of that of acids. At this stage the origin of the name alkali is explained, and it is pointed out that the oxides which have been studied may be arranged in two groups of alkali-like or *alkylic* and acid-forming or *acidic* oxides, the former being derived from metals, the latter from non-metals. The production of *salts* by the union of an oxide of one class with the oxide of the other class is then illustrated by reference to earlier experiments.

The point is now reached at which the results thus far obtained may be reconsidered. The student has been led in many cases to make discoveries precisely in the manner in which they were originally made; and it is desirable that at this stage, if not earlier, the history of the discovery of the composition of air and water, etc., should be briefly recited. It is then pointed out that a variety of substances have been analyzed and resolved into simple substances—air into oxygen and nitrogen, water into oxygen and hydrogen, etc.; and that these simpler substances thus far have resisted all attempts to further simplify them, and are hence regarded as elements. A list of the known elements having been given, the diverse properties of the elements may be illustrated from the knowledge gained in the course of the experiments. The fact that when elements combine, compounds altogether different in properties from the constituents are formed also meets with manifold illustration. Too little has been ascertained to admit of any general conclusion being arrived at with regard to the proportions in which elements combine, but it is clear that they may combine in more than one proportion, since two oxides of carbon have been discovered, and in the only cases studied—viz., copper oxide and chalk—the composition had been found not to vary. The existence of various types of compounds has been recognized, and a good deal has been learnt with reference to the nature of chemical change. But above all, the method of arriving at a knowledge of facts has been illustrated time after time in such a manner as to influence in a most important degree the habit of mind of the careful student. New facts have been discovered by the logical application of previously discovered facts: the logical use of facts and the habit of using facts have been inculcated. This is all-important. It has become so customary to teach the facts without teaching how they have been discovered that the great majority of chemical students never truly learn the use of facts; they consequently pursue their daily avocations in a perfunctory manner, and only in exceptional cases manifest those qualities which are required of the investigator; their enthusiasm is not awakened, and they have little desire or inclination to add to the stock of facts. It must not for one moment be supposed that the object of teaching chemistry in schools is to make all chemists. Habits of regulated inquisitiveness, such as must gradually be acquired by all who intelligently follow a course such as has been sketched out, are, however, of value in every walk of life; and certainly the desire to understand all that comes under observation should as far as possible be implanted in every one.

STAGE V.—THE QUANTITATIVE STAGE.

The *quantitative* composition of many of the substances which have previously been studied qualitatively should now be determined—in some cases by the teacher in face of the pupils, so that every detail may be observed and all the results recorded; in other cases by the pupils.

The composition of water is first determined by Dumas' method; this may easily be done, and fairly accurate results may be obtained in the course of a couple of hours. The results obtained by Dumas and subsequent workers should then all be cited, and attention having been drawn to the extent to which such experiments are necessarily subject to error, the evidence which the results afford that hydrogen and oxygen combine in certain *fixed and invariable proportions* to form water is especially insisted upon.

The composition of chalk gas is next determined; this also is easily done, as impure carbon (lampblack) may be burnt and the hydrogen allowed for. Again, attention is directed to the results obtained by skilled workers, and the evidence which they afford that chalk gas never varies in composition.

The composition of copper oxide has already been ascertained; it may be redetermined by reducing the oxygen in hydrogen; in fact, in determining the composition of water.

The lead oxides may be reduced in a similar manner, the oxide obtained by igniting white lead as well as red lead and the brown oxide obtained by treating red lead with nitric acid being used. In this way it is ascertained that the brown oxide is the highest oxide; the loss in weight which this oxide suffers when ignited may then be determined.

Tabulating the results thus obtained, after calculating with what amount of the particular element that quantity of oxygen is associated which in water is combined with one part by weight (*unit weight*) of hydrogen, numbers such as the following are obtained:

1 part of hydrogen is combined with 8 parts of oxygen in water.

3 parts of carbon are combined with 8 parts of oxygen in chalk gas.

31·5 parts of copper are combined with 8 parts of oxygen in copper oxide.

103·5 parts of lead are combined with 8 parts of oxygen in lead oxide (litharge).

51·8 parts of lead are combined with 8 parts of oxygen in lead oxide (brown).

These clearly illustrate the fact that elements combine in very different proportions, and the results obtained with the lead oxides afford also an illustration of combination in multiple proportion.

The amounts of silver and lead nitrates formed on dissolving silver and lead in nitric acid are next determined by evaporating the solutions of known weights of the metals in porcelain crucibles on the water bath, and then drying until the weight is constant; accurate results may be easily obtained, and these two exercises afford most valuable training. The nitrates are subsequently evaporated with muriatic acid and the weights of the products determined. What are these products? Does the metal simply take the place of the hydrogen in hydrogen chloride as zinc does when it dissolves in muriatic acid? If so, the products are silver and lead chlorides, and it may be expected that the same substances will be obtained—that the same increase in weight will be observed, when, say, silver is combined directly with chlorine as when it is dissolved in nitric acid and the solution is precipitated with muriatic acid or salt. Silver is, therefore, heated in chlorine, and is found to increase in weight to the same extent as when it is dissolved in nitric acid, etc.; a given weight of silver precipitated by salt is also found to increase to the same extent as when it is directly combined with chlorine. The composition of silver chloride having thus been ascertained, the amount of chlorine in salt is determined. The composition of salt being ascertained, purified dried washing soda is converted into salt, and also the amount of chalk gas which it contains is determined; from the data, the composition of sodium oxide may be calculated. In like manner the composition of lime may be ascertained by converting chalk into chloride by igniting it in hydrogen chloride, and then determining the chlorine in the chloride; the same method may be applied to the determination of the composition of the oxides and chlorides of zinc, magnesium, and copper.

Discussing these various results, and comparing the quantities of oxygen and chlorine which combine with any one of the metals examined, it is seen that in every case about 35·4 parts of chlorine take the place of 8 parts of oxygen. Combination in *reciprocal proportions* is thus illustrated, and by considering the composition of chalk and washing soda it may be shown that this applies equally to compounds of two and to compounds of three elements. As 35·4 parts of chlorine are found in every case to correspond to 8 parts of oxygen, it is to be expected that hydrogen chloride contains one part of hydrogen in combination with 35·4 parts of chlorine; a solution containing a known weight of hydrogen chloride is, therefore, prepared by passing the gas into a tared flask containing water, and the chlorine is then determined.

It being thus clearly established what are *equivalent* weights of elements, the conception of equivalents may be further developed by exercises in acidimetry carried out by the pupils themselves. The proportions in which washing soda and hydrogen chloride interact may be determined by mixing solutions of known strength until neutralization is effected; if the solution be evaporated and the chloride weighed, the results may be used in calculating the composition of hydrogen chloride; they serve, in fact, as a check on the conclusions previously arrived at as to the composition of washing soda and hydrogen chloride.

Solutions of sulphuric and nitric acid may be similarly neutralized, and, the amounts of sulphate and nitrate formed having been ascertained, the equivalents of the acids may be calculated on the assumption that the action is of the same kind as takes place in the case of hydrogen chloride.

Determinations of the strengths of acids, etc., may then be made. In a similar manner the volumetric estimation of silver may be taught, and the percentage of silver in coinage and other alloys determined.

Such a series of quantitative exercises as the foregoing, when carried out *before* and to a considerable extent *by* the pupils, undoubtedly affords mental discipline of the very highest order, and is effective of good in so many ways that the value of such teaching cannot be overestimated.

The failure to grasp quantitative relationships which examiners have so frequently to deplore is without question largely, if not alone, due to students' entire ignorance of the manner in which such relationships have been determined.

Moreover, the appreciation by the general public of the principles on which quantitative analysis is founded would undoubtedly be directly productive of good in a multiplicity of cases.

STAGE VI.—STUDIES OF THE PHYSICAL PROPERTIES OF GASES IN COMPARISON WITH THOSE OF LIQUIDS AND SOLIDS—THE MOLECULAR AND ATOMIC THEORIES AND THEIR APPLICATION.

A series of quantitative experiments on the effect of heat on solids, liquids, and gases should now be made, and these should be followed by similar experiments on the effect of pressure; the similar behavior of gases, and the dissimilar behavior of liquids and solids, is thus made clear.

The condensation of gases is then demonstrated and explained, and also the conversion of solids and liquids into gases, and the dependence of boiling point on pressure and temperature.

Regnault's method of determining gaseous densities is studied, and the method of determining vapor densities is illustrated. The molecular constitution of a gas is now discussed; the phenomena of gaseous and liquid diffusion are studied, and a brief reference is made to the kinetic theory of gases; then Avogadro's theorem is expounded and applied to the determination of molecular weights, and eventually the atomic theory is explained, and the manner in which atomic weights are ascertained is brought home to the pupils. The use of symbols must then be taught. Finally, the classification of the elements in accordance with the periodic law should be explained.

It is all-important that at least a large proportion of the experiments in each of the stages should be made by the pupils; but even if this were not done, and the lessons took the form of demonstrations, much valuable instruction might still be given.

The majority of pupils probably would not proceed to the fifth and sixth stages; but those who perforce must terminate their studies without gaining any knowledge of chemical philosophy should unfailingly be led to make a few simple quantitative experiments; for example, to determine silver volumetrically, and the method of determining the composition of water and chalk gas should be demonstrated in their presence; and it may be added that, if only the examples in Stages I. and II. and Problems I. to V. of Stage III. were thoroughly worked out, most important educational training would be given, and much valuable information as to the nature of common phenomena would be gained.

The complete course would undoubtedly take up considerable time, but so does a satisfactory mathematical or classical course of study, and it is absurd to suppose that useful training in science is to be imparted in a few months. If instruction be given in the manner suggested at all generally, it will be necessary, however, to modify the present system of testing results. Pupils could not be expected to pass at an early age examinations such as are at present held, and awards would have to be based chiefly on an inspection of the classes at work and of note books and on *viva voce* questioning.

But all are agreed that the present system of payment on results tested by a terminal examination is a most unhealthy one, and that a more rational system *must* be substituted for it.

I may suggest that if members of the staff of science colleges, such as are now established in so many towns, could be appointed *supervising inspectors*, whose duty it would be to advise teachers in schools and *occasionally* to inspect the teaching in company with the permanent inspector, it would be possible to secure the assistance of a body of men who are in touch with scientific progress and conversant with the improvements which are being effected.

A man who "once an inspector is always an inspector" of necessity must get into a rut, and will escape from the wholesome leavening and rousing influence which is always more or less felt by those whose office it is to follow the march of scientific progress.

It should also here be pointed out that the great majority of the experiments and exercises described may be carried out with very simple apparatus, and with slight provision in the way of special laboratory accommodation.

In but very few cases is there any production of unpleasant smells or noxious fumes. It is, in fact, a mistake to suppose that an elaborately fitted laboratory is in every case essential for successful teaching; much might be done in an ordinary schoolroom provided with a demonstration bench for the use of the teacher, a draught closet over the fireplace, a sink, a raised table for balances (raised so that the teacher might see what was going on), a cupboard for apparatus, and a long narrow bench provided with gas burners at which, say, twenty pupils might stand, ten a-side.

At present the Science and Art Department will not recognize "practical chemistry" unless it be taught in a laboratory fitted up in a certain specified manner, and their regulations are such as to enforce the provision of expensive laboratories in all cases where it is desired to obtain the grant.

If greater latitude in fittings were allowed, more attention being paid to the character of the work done and less to the tools with which it is accomplished, probably much less money would be wasted by inexperienced school authorities in providing special laboratories, and there would be much greater readiness displayed to enter on the teaching of experimental science.

The course which has been sketched out is one which doubtless might well be modified in a variety of ways according to circumstances. Thus many simple exercises in mechanics, in addition to those directly mentioned, might be introduced into Stage II., and the mechanical properties of common materials might be somewhat fully studied at this stage in districts where engineering trades are largely established, and where such knowledge would be specially valuable.

In like manner the physical effects of heat on substances might be studied in Stage III. instead of Stage VI. And there are other chemical problems and simple exercises besides those described which might be substituted for some of them, or included in the course.

Probably, however, it would be found undesirable, if not impossible, as a rule, to continue the teaching of chemistry proper much, if at all, beyond the stage indicated in the scheme.

Other subjects will have a prior claim should it ever be deemed essential to include in a comprehensive scheme of school education the elements of the chief physical and physiological sciences; it certainly is of primary importance to introduce at as early a period as possible the conception of energy, and to explain the mechanical theory of heat, so that later on it may be possible to discuss the efficiency of heat and other engines; and until the laws of the electric current are understood, the subject of chemical change can never be properly considered.

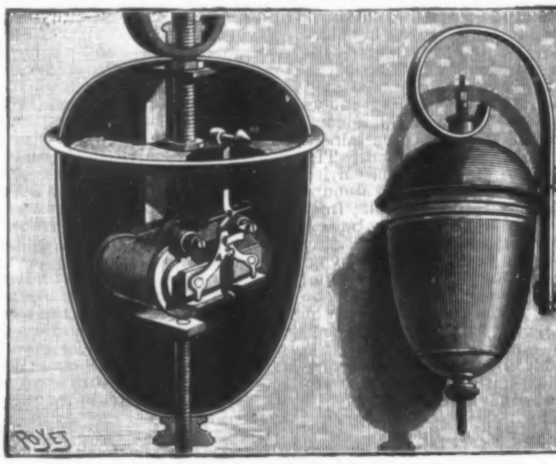
In many cases, where it is convenient or desirable to continue the chemical studies, it probably will be ad-

vantageous as a rule that they have reference to specific (local) requirements—*e. g.*, to agriculture in schools in agricultural districts; to food materials and physiology, in the case of girls especially, etc. But in any case more consideration must be paid in the future in schools where chemistry is taught to educational requirements—the teaching must have reference to the requirements of the general public; and it must be remembered that the college, not the school, is the place for the complete study of a subject.

BOREL'S ELECTRIC BELL.

THERE are few domestic apparatus upon which the imagination of inventors has been exerted with so much perseverance as electric bells.

The model represented herewith, which was exhibited in the machinery palace of the exposition, seems to give a satisfactory beginning to the present exigences of household ornamentation. The mechanism of this bell is entirely hidden in a metallic shell of ovoid form, to which may be given an aspect in harmony with the general tone of the room in which it is installed, by bronzing, nickel plating, silvering or gilding it, according to circumstances. It may be placed against a wall, upon a table, in the center of a ceiling or elsewhere. The mechanism is protected against dust and moisture, and the manner in which it is mounted renders it unlikely to get out of order. This mechanism itself presents some new and interesting arrangements. The hammer, *m*, is mounted entirely independent of the armature of the electro-magnet. This armature, pulled backward by a spiral spring, strikes at every emission of the current the bottom of the lever, B *m*, supporting the hammer, *m*. Giving an impulsion to this, it throws it against the bell. The effect of this motion is to break the circuit, which is not closed again until the hammer is drawn back. The result of such an arrangement, which is entirely new in an electric bell, is that the interval of time that elapses between two successive strokes is independent of the tension of the spring and, in a certain measure, even of the intensity of the current that actuates the bell. This interval of time is a function of the duration of oscillation of the pendulum formed by the hammer and the rod that supports it. The result is that the strokes succeed one another very regularly, and with an always equal intensity, this being one of the most valuable qualities for preserving in every call bell its character for distinctive sonorousness.



NEW ELECTRIC BELL.

It is unnecessary to say that the arrangement is equally well adapted for use with lignum vitæ, steel or bronze bells, in order to permit of easily distinguishing the different calls. It is, upon the whole, an interesting improvement upon an apparatus which was thought incapable of improvement, and which Mr. Borel has revivified by giving it an original form and arrangement.—*La Nature.*

[REPORTS FROM THE CONSULS OF THE UNITED STATES.]

COOKERY FOR WORKINGMEN'S WIVES.*

Report by Consul UNDERWOOD, of Glasgow.

WASTE IN COOKING.

THE following table shows how much is wasted in some of the different ways of cooking:

Four pounds of beef, in boiling or stewing, wastes about 1 pound of its substance; but you have it all in the broth or gravy, if you have kept the pot closely covered.

In baking 1¼ pounds is almost entirely lost, unless you have plenty of vegetables in the dripping pan to absorb and preserve it.

In roasting before the fire you lose nearly 1¼ pounds. Do not think you save the waste in the shape of dripping. Is is poor economy to buy fat at the price of meat merely for the pleasure of frying it out.

GENERAL HINTS.

It is very desirable that all cooked food should be taken hot. When cold food is taken, it reduces the temperature of the stomach; and both the nerves and vessels of the stomach are taxed, in order to bring the temperature of the food thus taken up to that of the human body. So in taking hot soup, tea, coffee, or cocoa we prevent this tax upon the internal organs. When people have been overexerted or had a long fast it is better for them to have a little hot soup or a cup of cocoa, and wait for half an hour before they take their dinner; by that time they are rested, the hot soup or cocoa has refreshed and invigorated the stomach as no wine or spirit could have done.

Before beginning to cook be careful to see that you have a clear fire in a clean grate, and that your pots and pans are thoroughly clean. To clean pots, first clean the inside out well with pot range, then wash them both inside and out with hot water and some washing soda; then take a cloth, with a little soap rubbed on it, dip it in fine ashes, with this rub the inside of the pot till it is quite clean, then wash it with warm water and dry. Do the lid in the same way.

Fish, if at all plentiful, is always cheaper on Thursdays, Fridays, and Saturdays, and can be had at the time the shops close at less than half price, if they have any over. For those who study economy this is worth remembering, as they can thus provide a good cheap dinner for the next day.

Pieces of dry cheese, which the grocers are glad to get rid of very cheap, do excellently for cooking and grating.

Soap parings in the same way can be got very much cheaper, and are quite as good for boiling down for washing purposes.

HINTS ON WASHING, ETC.

Washing is always best done early in the week, say Tuesday. Then you have the week before you to dry, etc. Mend what requires to be mended the day before. Soak your things before washing; if this is done, it saves a great deal of trouble and hard rubbing. Boil the soap, and mix a handful of boiled soap to every gallon of hot water, with a little soda or borax (borax is better for fine things). Into this put the shirts and linen, collars, etc., to soak all night. Bed and table linen can either be soaked in cold water or laid aside till its turn comes. Curtains or window blinds should always be soaked in cold water to draw out the smoke.

Flannels should be well shaken, to free them from dust, and put together by themselves.

Begin your washing as early as possible in the morning. First light your boiler fire and have plenty of hot water. If it is fine, wash your flannels first. Add a little hot water to the soaked things, taking the best things first. Wash them out carefully, removing all stains. Then put them into another tub with warm water and melted soap, and wash them again; and as they are finished, drop them into a tub of cold water and let them lie in it for a while.

Fill up the boiler with cold water, put into it a handful of melted soap, 1 teaspoonful of borax to the gallon of water. Wring the clothes out of the cold water, put them in the boiler, put on the lid, and let them boil gently for a quarter of an hour. Then take them out, add more water, soap, and borax, and put in the next quantity. Pour some cold water on the boiled clothes, wash them and rinse them out, then blue them. Put a little water in the tub and tinge it well with blue. Do not allow things to lie in blue water, but just dip each article in separately, and ring them out. When all are finished, hang them out to dry.

If possible, bleach your clothes on grass after boiling; but where this cannot be done it is yet possible, with care, to keep your linen white and clear.

Laces and muslin should not be rubbed, but squeezed with the hands in melted soap and warm water. Be careful, in boiling them, to tie them up in a handkerchief to prevent their being torn.

In washing flannels (notice particularly), to keep them a good color and to prevent their shrinking, get from the grocer 1 or 2 pounds (according to the size of your washing) of soap parings, which you will get cheap; for 1 pound of soap parings put 3 quarts of water: boil to a jelly, and with this wash your flannels. Be sure you have plenty of water warm, not too hot. Put in a handful of your soap jelly, and mix thoroughly in the water; then take the flannels, one at a time, shake all dust out of them first, then sluice the articles up and down well; rub as little as possible, for rubbing knots the little loops of wool together and thickens the flannel; wring them in a machine, if you have one, if not, squeeze them well. Dry in the open air, if weather permits, as quickly as possible.

In washing scarlet or blue flannel, put one tablespoonful spirits of ammonia in the rinsing water.

For other woolen articles, such as children's dresses, shawls, etc., where there are green or other fancy colors, add to your soap jelly one-half gill of spirits of turpentine and a tablespoonful of spirits of hartshorn; then thoroughly wash as quickly as possible; rinse in cold water with a little salt in it, and dry quickly. If this is done carefully, the colors will remain quite fresh.

For Prints.—Never rub them with soap. Boil the soap as for flannel, add to water, and wash as quickly as possible; then in the rinsing water put a few drops of vitriol, just sufficient to make it taste a little tart; this will fasten all colors except black, but black fades. For black prints better use salt or a little spirits of turpentine in the rinsing water.

To Make Hot Water Starch.—Take a clean basin, and mix to 1 large tablespoonful of starch, 1 teaspoonful spirits of turpentine, a teaspoonful spirits of ammonia, with only enough cold water to make into a smooth paste; then pour boiling water (it must be boiling) over it, stirring all the time till it is quite transparent.

To Make Cold Water Starch.—To a large tablespoonful of starch put half a teaspoonful borax, half a teaspoonful spirits of turpentine, mix with a little cold water to a paste; then add cold water to make the starch to the thickness of cream; stir well, and put in the things; if the things to be starched are dry, you will have to make the starch thinner.

To Starch and Iron a Shirt.—The linen should be rather damp; dip the front, collar, and cuffs of shirt into the starch, squeeze them well out, and roll up tight for some hours; then shake out and pull them quite straight, leaving no creases; rub them over with a piece of soft cloth. Fold the shirt straight down the back. Iron all the unstarched parts first, then the cuffs, then the band. To gloss the front place a smooth board, covered with flannel, inside the breast, rub over the front of the shirt with a damp cloth, and iron with the heel of the iron very nicely till quite dry and glossy.

In ironing be careful always to rub the iron over something of little value first; this will prevent the scorching and smearing of many articles.

To Wash Clothes with Paraffine Oil.—To every eight gallons of cold water, put one-fourth pound soap, shred fine, 1½ tablespoonfuls paraffine oil, into a boiler; put in the clothes, let them come to the boil, keep the lid close on boiler, and steam for half an hour; take out the clothes, rub any parts not quite clean, and rinse in plenty of cold water.

To Wash Clothes in Paraffine Soap.—Cut down one-half pound paraffine soap, and put it into a boiler of water to melt. Rub the clothes well out of the soda water, in which they have previously been soaked, put them into a boiler and let them boil for half an hour, then put them into a tub with plently of cold water; wash them thoroughly, then rinse in blue water, and dry

SANITARY HINTS.

(1) Remember that pure air is food, and that polluted air is poison.

(2) Never allow the air to stagnate in your rooms or houses.

(3) Provide for the constant ventilation of your rooms. One of the best ways of doing this is keeping the window a little down from the top.

(4) Keep the vent always open.

(5) Thoroughly air all sleeping apartments, beds, and bed clothes during the day.

(6) Do not use, for drinking or cooking, water which has long lain stagnant in cisterns or vessels.

(7) See that the water cistern is cleaned out regularly, say every month or two.

(8) See that there is no connection between the water cistern and the drain, and that the waste goes to the outside of the house.

(9) Do everything in your power to keep closets and sinks cleanly and sweet.

(10) See that the private drains from closets are ventilated by pipe opening at the roof.

(11) See that the private drains from closet and sinks are properly trapped, in order that the poisonous gases from the sewers may not get into the house.

(12) The neglect of this precaution is a fruitful cause for many of the worst diseases, such as diphtheria, typhoid fever, etc.

(13) When you need to use disinfectants, as after fever, etc., remember that they do not radically cure the evil. The only remedy is the removal of the causes of impure air or water which have produced the evil.

(14) Avoid the use of covered (or "press") beds, the most wholesome being a plain iron bed without any curtains.

(15) In case of sickness all utensils, etc., should be kept scrupulously clean, and the precautions suggested above as to maintaining a supply of pure air should be observed with redoubled vigilance.

HINTS ON WHAT TO DO BEFORE THE DOCTOR COMES.

Croup.—Croup, or inflammatory sore throat, is caused by the exposure to cold, damp air, or sudden change of weather. The signs are hoarseness and noisy breathing. Give the child a teaspoonful of ipecacuanha wine. If vomiting does not soon follow, give half the quantity. Keep the child in bed. Put a brick into the fire until it is quite hot; place a bucket of water at the bedside; put the hot brick into it, which will raise a large quantity of warm vapor, which the child will breathe. Apply a warm poultice to the throat and use warm fomentations. Milk is the best diet. If the above does not relieve, send for medical advice without delay.

A very good and simple remedy for croup is a teaspoonful of powdered alum and 2 teaspoonfuls of sugar; mix with a little water and give it, as quickly as possible, a little at a time, and instant relief will be given.

Diphtheria.—What goes by the popular name of croup is, in a great many instances, really diphtheria, which is a contagious general disease of great danger. The chief characteristic is the formation of a thick, tough, false membrane on the palate, tonsils, and back of the throat, spreading downward into the windpipe. The signs are great loss of strength (never absent), the formation of the above named membrane, sometimes high fever, as often no rise in the temperature. Sometimes eruptions in the skin appear. Whenever the above signs can be traced, get medical advice without amoment's delay.

Common Cold.—In the case of a child, confine the child to one room, or, if at all feverish, to bed. Apply a warm poultice to chest, and give 10 drops of ipecacuanha wine every hour or two till patient perspires and feels a little sick. In the case of a grown-up person, confine to house and keep patient warm. Mix 30 drops antimonial wine, 80 grains of citrate of potash, 3 teaspoonfuls of sirup, or a little sugar, in 4 ounces of water (an ounce is 2 tablespoonfuls). Give an ounce of this every three or four hours. If the cough lingers a teaspoonful of paregoric, with 20 drops of ipecacuanha wine in a little water, should be given at bed time.

Useful Homely Recipe for a Cold and Cough.—One ounce Spanish juice, 2 ounces honey, one-half pound treacle, 1d. worth laudanum, 1d. worth oil of peppermint, 1 pint of water.

Boil down 1 pint of water, with the Spanish juice, honey, and treacle in it, to a gill; let it get cold, and

* Continued from SUPPLEMENT, No. 734, page 11733.

add laudanum and oil of peppermint. Bottle tight, and shake the bottle before using. Dose for an adult, a tablespoonful night and morning.

Fainting.—At once make patient lie down, with the head quite low. Loosen articles of dress. Let patient have plenty of air, and keep people from crowding round. Apply smelling salts, cautiously, to nose. Sprinkle face with a little cold water smartly. If faint continues long, or feet and hands are cold, apply hot bottles, and when patient can swallow give a teaspoonful of sal volatile in water, or a little spirits in water.

Fits.—This means either apoplexy or epilepsy. Apoplexy is attended with insensibility. The patient falls, generally, but not always, grows purple in the face, and breathes in a snoring manner. There is paralysis of one side, and the mouth is drawn to one side. Place patient in bed, with head raised. If hot, apply cold water to head, and send for doctor.

In epilepsy, patient usually gives a scream, becomes deadly pale, falls on his face, becomes convulsed, and then profoundly insensible. While in this state all that need be done is to loosen articles of dress and keep patient quiet and beyond danger of hurting himself until sensibility returns. It is then a case for medical treatment.

Choking.—Choking arises from food, or fluids, or other substances sticking in the throat or passing into the air passages. In bad choking, where the patient suddenly turns dark in the face, etc., no time is to be lost. Open the mouth and push your forefinger in a determined way over the tongue, right back, and try to hook away or push aside the hinderance. If this does not succeed, you may, by pressing the hinder portion of the tongue, bring on vomiting and so secure relief. A good plan is sometimes tried with children, viz., that of pressing the chest and stomach against something hard, as a table or a chair, then slapping or thumping the back between the shoulder blades. In this way air is driven from the lungs through the windpipe so forcibly as often to expel the obstacle. When the obstruction consists of a coin, as often in the case of children, a good plan is at once to take the child up by the heels and at the same time give it a shake or slap its back. Fish bones can sometimes be got rid of by swallowing a mouthful of bread. If these remedies fail, medical help should at once be called in.

Suffocation by Gases.—Drag the patient as quickly as possible into fresh air, loose clothing, dash cold water on head, face, and upper part of chest. If the breathing has stopped, artificial respiration must be resorted to.

Poisoning.—Send at once for the nearest doctor, telling him all the particulars, so that he may bring what is necessary. Unless the poison is an irritant, such as oil of vitriol or the like, which burns or destroys the stomach, etc., do all you can to make the patient sick. You may give a tablespoonful of mustard in a tumbler of warm water, or the same amount of common salt with warm water. If the patient is drowsy, as from poisoning by narcotics, you must do all you can to keep him awake by dashing cold water on his head and face, walking him about, etc. Do not permit him to sleep. In cases of poisoning by irritants emetics should not be given, but you should try to save the stomach as much as possible by giving soothing drinks, as milk, etc. Always try to find out what the poison taken has been. You will generally be able to recognize a case of irritant poison, even if the patient cannot tell you, by the stains on the clothes, lips, etc., the burning sensation of the mouth, the terrible suffering of the stomach, the retching, and vomiting of blood, etc. Medical advice must in any case of poison be called in with the utmost haste.

Poisoning by Alcohol, or Drunkenness.—Get the patient under cover as soon as possible. If insensible, rouse him by dashing cold water on the face. Endeavor to make the patient vomit. Rub the surface of the body with warm, dry cloths; wrap the patient in blankets; put hot water bottles to his feet, and do all you can to keep up the heat of body, which is always lowered in the state of intoxication.

Broken Limbs.—The thing to be first done is to keep the limb quite steady till the surgeon comes. This is done by placing on each side of the broken limb whatever may be at hand, such as slips of wood, small pillows, an umbrella, the stock and barrel of a gun, or two walking sticks, or even firmly rolled straw, or pads of cotton wool, and retaining them in their position by one or two handkerchiefs, not tied too tightly. Never raise the patient from the ground until the nature of his injury has been ascertained, or some appliance has been made to prevent the movement of the broken limb. Then raise him, if possible, with the help of several persons, and, as it were, in one solid piece, all moving together, and keeping step in carrying. If a patient has to be carried home, let it be on a shutter, or a table, or a stretcher, on which he can lie flat, instead of being doubled up in a cab, as is often done. It is from neglect of this simple rule that broken bones are often made to protrude through the flesh, simple being thus turned into compound fractures, attended by the risk of the limb being lost.

Restoration from Drowning.—The directions for restoring persons apparently drowned would take up too much space for such a book as this, but they can be got from the Royal Humane Society, and should be in the possession of all persons specially exposed to risk, or likely to deal with such cases.

What to Do when Dress Catches Fire.—The following are the directions given in Dr. Robert's book on ambulance work: "If your own dress, throw yourself at once on the ground, so that the rising flames may not catch the upper part of your clothes nor burn your head and chest; roll about (so putting the flames out by pressure), and at the same time, if possible, wrap yourself up closely in a rug, hearth rug, blanket, table cloth, overcoat, or carpet, so as to smother the fire. Do not get up to call for assistance, but for that purpose crawl to the bell rope or door. If another person's dress, throw the person on fire down at once, wrap him or her up in a rug or something similar, or if there is nothing at hand suitable, use your own coat, rolling the patient about in it, for the purpose of smothering the flames." A woman rendering help in this way must exercise great self-possession, and be careful not to get her own clothes entangled in the flames.

Measles and Scarlet Fever.—When measles or infectious diseases are prevalent in a neighborhood and a child shows symptoms of cold in the head and fever, it is a reason for immediate carefulness. The diet should be light, cooling, scanty, and the child should be kept indoors. In its ordinary course measles is unaccompanied by danger, but the mildest form may be quickly converted, by want of care, into the most dangerous. The parent should carefully watch the symptoms of change, and if a child complains of piercing headache, intolerance of light, etc., the doctor should be called in at once. It is also most dangerous to resort, without advice, to spirits and such remedies to bring out the rash if it suddenly disappears. Sometimes the disappearance of the rash may be traced to careless exposure to cold. In this case the child should be instantly, and without hesitation, put into a warm bath, care being taken to prevent subsequent cold. Often, however, the cause of the disappearance may be dependent on internal inflammation or too high fever, and medical advice should be at once procured.

Indigestion.—Among the most common causes of indigestion are the undue use of strong or too long infused tea (which taken without food and in excess is destructive), the use of new bread, and eating too fast.

Teeth.—If people wish to preserve their teeth they should brush them, especially at night, gently with a short, soft brush, moved up and down so as to remove remnants of food, etc., lodging between the teeth and so destroying the enamel. This precaution involves little or no expense, and the trouble will be well repaid. When iron tonics or acid mixtures have to be taken, they should always be sucked through a glass tube, which can be got at any chemist's for a penny or two. Doctors often forget to remind patients of this, and, in consequence, the teeth grow prematurely black or loosen and decay.

Recovery from Sickness.—When patients are recovering from measles and scarlet fever, the greatest care must be taken to avoid chills. From the neglect of this precaution after-consequences of the most serious character often occur. Children recovering from these illnesses should be warmly clothed and kept out of cold draughts until they have quite regained strength. It is also the duty of parents who have children suffering from the above diseases to prevent healthy people from coming near them, particularly in the case of scarlet fever, until the stage of peeling of the skin is quite over, when the patient should be well washed with carbolic soap. The bed and bedding should be disinfected as well as the clothing.

Intoxicating Drink.—The abuse of intoxicating drink is the curse of this country. It is the fruitful parent of crime, disease, premature death, and domestic misery in every shape and degree. The judges, with one accord, say that if the people could only be made to abstain from the use of intoxicating drinks, more than half the prisons might be shut up. Men and women who are tempted to sin in this way should abstain entirely. For these there is but one rule of safety—taste not, touch not. Industry, thrift, and strict temperance, these are the simple rules which, by the divine blessing, secure health and lasting happiness.

THE HALL PROCESS FOR MANUFACTURE OF ALUMINUM.

THIS process, that is now stated to be in successful operation in Pittsburg, and by which the price of the metal has been greatly reduced, is described by the inventor, Charles M. Hall, of Oberlin, Ohio, as follows: I form an electrolyte or bath of the fluorides of calcium, sodium, and aluminum, the fluorides of calcium and sodium being obtained in the form of fluor-spar and cryolite, respectively, and the fluoride of aluminum being obtained by saturating hydrated alumina (Al_2HO_6) with hydrofluoric acid. The compound resulting from the mixture of the above mentioned fluorides, which is represented approximately by the formula $Na_2Al_2F_6 + CaAl_2F_8$, is placed in a suitable vessel, 1, preferably formed of metal and lined with pure carbon, for the purpose of preventing the admixture of any foreign material with the bath or with the aluminum when reduced. The vessel 1 is placed in a furnace, 2, and subjected to sufficient heat to fuse the materials placed therein. Two electrodes, 3 and 4, of any suitable material, preferably carbon, when pure aluminum is desired, and connected to the positive and negative poles of any suitable generator of electricity, preferably a dynamo-electric machine, are placed in the fused bath, or, if desired, the carbon-lined vessel may be employed as the negative electrode, as represented in dotted lines. Alumina in the form of bauxite, anhydrous oxide of aluminum, or any other suitable form of alumina, preferably the pure anhydrous oxide Al_2O_3 artificially prepared, is then placed in the bath, and, being dissolved thereby, aluminum is reduced by the action of electric current at the negative electrode, and being fused by the heat of the bath sinks down to the bottom of the vessel, the bath being of a less specific gravity than the aluminum. This difference in specific gravity is an important feature of my process, as the superincumbent bath serves to protect the aluminum from oxidation. The oxygen of the alumina is liberated by the action of the electric current at the positive electrode, and, when the latter is formed of carbon, combines therewith and escapes in the form of carbonic oxide (CO) or carbonic acid (CO_2).

As the aluminum is reduced, more alumina is added, so that the bath may be maintained in a saturated condition with the fused alumina. The addition of more alumina than can be dissolved at one time is not detrimental, provided the bath is not chilled, as such excess will sink to the bottom and be taken up by the bath, as required.

The proportions of the materials employed in forming the bath or the electrolyte are approximately as follows: Fluoride of calcium, two hundred and thirty-four parts; cryolite, the double fluoride ($Na_6Al_2F_{12}$), four hundred and twenty-one parts; and fluoride of aluminum, eight hundred and forty-five parts by weight. These proportions can, however, can be widely varied without materially changing the efficiency of the bath. During the reduction of the aluminum the positive electrode, when formed of carbon, is slowly consumed and must be renewed from time to time, but the bath or electrolyte remains unchanged for a long time. In time, however, a partial clogging occurs, which, however, does not render the bath wholly ineffective, but does necessitate an increase in the electro-motive force of the reducing current, the resistance of the bath being increased in proportion to the degree to which the bath becomes clogged, thereby increasing the cost of reduction. In order to entirely prevent any clogging of the bath, I add approximately three or four per cent. (more or less) of calcium chloride to the bath or electrolyte hereinbefore described. As the addition of the calcium chloride prevents, as stated, any clogging or increase of resistance in the bath, it can be used continuously without renewals or any additions, except such as may be needed to replace loss by evaporation, and without increasing the electro-motive force of the reducing current, and, further, the addition of the calcium chloride enables each atom of carbon of the positive electrode to take up two atoms of oxygen, forming carbonic acid (CO_2), thereby reducing the amount of carbon consumed in proportion to the amount of aluminum produced. The calcium chloride being quite volatile is subject to loss faster than the rest of the bath, and must be renewed occasionally on this account.

In reducing aluminum, as above described, I prefer to employ an electric current of about six volts electro-motive force, but the electro-motive force can be varied within large limits.

THE SPECTRUM AND ITS DEVELOPMENT.

By GERALD F. YEO.

EVERY one is familiar with the beautiful play of colors shown when white light is broken up into its component tints.

These are seen when the sun, shining on a passing shower, produces a rainbow, or in the prismatic facets of crystal lusters when we look through them at a luminous object, and are the cause of the brilliant sparkle of the cut jewel as it flashes in the light. All these effects are due to the different colored rays of light being variously turned aside from their straight course on passing from the atmosphere through a denser medium, such as glass, crystal drops of water, or aqueous vapor. This colored image, derived from white light, is called its spectrum.

It is difficult for the uninitiated to realize the position of unique importance given by modern science to this prismatic play of colors. Yet none of the methods of discovery in use nowadays has attracted attention more rapidly or yielded richer fruit in several departments of science than spectral analysis. By it new power has been placed in the hands of scientific workers by which chemical investigations of extraordinary exactitude and delicacy can be accomplished with comparative ease and rapidity.

Not only has this method of analysis been the means recently of discovering several new elementary bodies within the narrow limits of our planet, but it extends our capability of research to the uttermost bounds of the heavens and brings the remotest celestial bodies and mysteries of astronomy within the range of exact analytical investigation. It might, in fact, be said that the spectrum supplied a new sense to the astronomer by means of which his telescope not only enabled him to see the heavenly bodies, but also to test their constitution and study their habits.

Some thirty years ago a chemist could hardly have believed that by an optical method minute quantities of substances could be recognized which escaped detection under the most searching examination by his methods of analysis; and an astronomer would have ridiculed the notion had he been told that in a few years we should have an exact knowledge of the composition of the sun, the most distant stars, and even of the mysterious nebulæ. To the ordinary mind even now it seems almost incredible that we can determine, with as great a degree of certainty as appertains to any conclusion in physical science, the chemical composition of the atmosphere surrounding heavenly bodies situated at a distance of millions of millions of miles from our earth.

Although practically the spectrum became a recognized method of analysis only some fifty years since, like all other so-called discoveries which open new roads to knowledge, the growth of spectroscopy has been gradual, and it cannot be said to have been born of the work of any one individual.

When we attempt a historical sketch of its early development as a means of research, we are led back through a long series of additions to our knowledge which extend over many years and consist of new facts and imperfectly understood discoveries recorded by numerous independent observers. These may be regarded as the raw material out of which the science of the spectroscope was built up and made a perfect method of investigation.

The first fact of importance, which may be regarded

as the foundation stone of all the great modern superstructure, was laid in England by a discovery made by Sir Isaac Newton. In the year 1675 he demonstrated the fact that ordinary white light was in fact a compound of all the colors seen in the rainbow. Each of the series of colored rays, shading from violet through blue, green, and yellow to red, can be made separately visible on a screen by means of a prism. He further showed that the various rays could be reunited by a second prism, so as again to produce on the eye the effect of white light. This splitting up into a series of colored rays is the decomposition of white light.

In his memorable experiments Newton allowed the ray of sunlight to pass through a round hole in a shutter to the prism, and then fall directly upon a screen. By this means an enlarged rounded image of the hole was thrown by each separate tint of color on the screen, and a brilliant diffused spectrum was produced. Owing to the round image projected by each kind of ray overlapping its neighbors, he obtained an uninterrupted series of colors. He therefore failed to observe some dark lines now well known to be characteristic of the pure solar spectrum.

In order to understand the *rationale* of spectroscopic analysis it is absolutely necessary to have some idea of the physical explanation of this decomposition of light.

All the differently colored rays which constitute white light consist of waves in an imponderable medium which physicists call ether. Each color has a different length of wave, those in a red ray being about twice as long as those in a ray of violet light. The vibration of the ether is, therefore, so much more rapid in the case of the violet.

When a beam of light passes obliquely from a medium such as air to a denser one such as water or glass, its direction is changed, so that it proceeds through the denser medium more at right angles to the surface than was the direction of its path on arrival, and *vice versa*, when the ray leaves the denser medium the direction of the beam of light is bent down from the right angle and made more oblique. If the two surfaces are parallel the beam continues on its exit in the same direction as on its entrance, but if the surfaces are not parallel, as in the case of a prism, the direction of the light is permanently changed. This bending or refraction is due to the fact that the rate of traveling of the light is reduced on entering and increased on leaving the denser medium. This retardation of the light does not affect its direction when it comes in a path exactly at right angles to the surface. But when the ray arrives in an oblique direction refraction takes place, because the retardation begins to take effect at one extremity of the approaching wave front before the other has reached the impeding medium, and, consequently, the latter extremity of the wave front moves onward more quickly for a moment than the impeded end, and thus the direction of the wave front is changed.

A rough comprehension of refraction may be gained easily by comparing the beam of light to a column of men marching forward at an even pace in a straight line. If the column comes straight to some obstacle lying at right angles to its line of march, and directly across its front, the direction of its course is not in any way changed, though the rate of progress may be lessened. But if the front line of the column meets the impediment which checks their advance—such as a river to be forded—in an oblique direction, one end of the line is sooner checked than the other. The men as they get into the water have to take shorter steps to keep time with their comrades on land, who, taking the same number of steps, get over more ground, so that while the men in the water advance say ten yards, the longer paces of those on land get over fifteen yards. The direction of the front of the column is thus caused to swerve a little from its former oblique path, and hence its line of march is changed to a course straight across the obstacle. If the banks of the river which is to be forded are parallel, this change of direction produced by entering the impediment is made up for on the other bank. The column on emerging swerves in the other direction, for the men who went in first also come out first, and taking longer paces on their exit, make more rapid progress than their comrades who are still in the water.

If a beam of light be substituted for the column, its change of direction, or refraction, may be similarly followed. When a ray of light enters a prism obliquely it is bent toward the base of the prism, and as it emerges from the second face it is again bent, because the rate of traveling of the ray of light is lessened on entering and increased on leaving the obstacle.

The impediment influencing one part of the wave front before the other causes a change in its direction, just as an oblique impediment changes the line of march of soldiers.

The shorter the length of the waves of a given ray of light, the greater will be the retarding influence of the denser medium. Owing to this fact, the quick waved violet light is more retarded, and, therefore, more bent or refracted than any other colored rays, and, on the other hand, red light is least bent on passing through a prism.

The intermediate colors having wave lengths varying between those of violet and red take up in the spectrum positions corresponding to the length and capacity of their undulations. By using a slit to admit the light to the prism each colored ray yields an image of a thin line, and by the juxtaposition of the images formed by all these separate rays a continuous spectrum of delicately graduated color is produced.

It will be readily understood that if any particular kind of ray, *i. e.*, shade of color, were absent from the source of light used, there would be a break or gap in the sequence of tints, and instead of a brightly colored image of the slit, a dark line or band would be seen in that part of the spectrum.

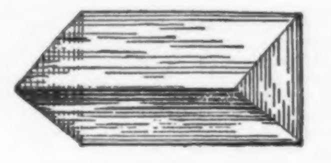
If, on the contrary, the source of light consists of only one or two kinds of rays, corresponding to one or two colors of the spectrum, then only one or two images of the slit could be seen, and these would not coalesce to form a continuous series of shades of color, but would produce as many bright bands as there were colored rays, separated by colorless or black gaps, corresponding in position with those rays not existing in the source of light used.

From this it may be gathered that it is possible to distinguish three kinds of spectra, which differ in their general characters and mode of production.

First, that of compound white light, in which the series of colors is not interrupted in any way, and the shading passes evenly from the violet to the red, all shades being equally represented. Such a spectrum is characteristic of the light emitted by incandescent solids or liquids, and is called a continuous spectrum.

Secondly, spectra in which a few colored rays here and there are deficient, so as to mark the spectrum with narrow dark lines. These dark lines are really gaps in the spectrum, showing that some ray of special color or wave length has been cut off on its way to the prism. These absorption spectra are seen when some transparent colored body lies in the path of the ray.

Thirdly, spectra obtained from a source of light which emits only one kind or a few kinds of colored rays, which after passing through the prism appear as a few corresponding bright lines; the rest of the spectrum remaining dark.



A PRISM.

This kind of "bright band" spectrum is characteristic of the light given out by bodies in the state of glowing vapor, as seen in flames colored by incandescent gaseous molecules.

EARLY WORKERS.

The first work published on the application of the prism to special purposes, entitled "On the Examination of Colored Flames by the Prism," by Thomas Melville, was printed in Edinburgh in 1752. He examined the prismatic colors through a hole in a piece of pasteboard, and with this primitive spectroscope became familiar with the remarkable phenomenon of the bright bands in the spectra of various flames, and he was much struck by the local bright band of the flame of spirits of wine and sea salt, but did not draw any useful conclusion from these preliminary investigations, and, unfortunately for science, he died two years later, at the early age of twenty-seven.

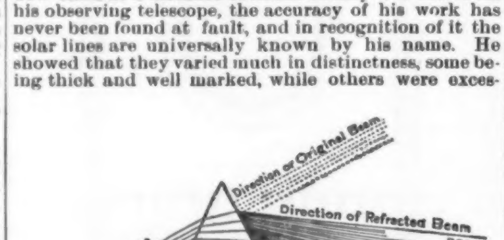
The first important step toward the accurate analysis of the spectrum was made by Wollaston. He caused light to pass through a narrow crevice in a dark blind on its way to the prism, and he thus discovered certain dark shadings in the spectrum, which fact he communicated to the Royal Society in the year 1802. By narrowing the aperture in the dark blind through which the light entered, only a very narrow pencil of light was admitted, and the separate colored rays were projected from the prism as very thin bands or lines—images of the crevice. Very little overlapping of the colors then occurred, and those parts of the spectrum where the luminous rays were wanted were indicated by dark shadows, over which the neighboring colors did not spread. He described five dark lines limiting the chief colors of the spectrum, and two finer ones.

He also examined the spectrum of a candle, which, he says, "instead of appearing as a series of lights continuous, may be seen divided into five images at a distance from each other."

The electric light he found also gave a different spectrum, but he adds: "It is needless, however, to describe minutely appearances which vary with the brightness of the light, and which I cannot undertake to explain."

In 1814 a German optician named Joseph Fraunhofer, while determining the refractive and dispersive power of different kinds of glass, with a view to making achromatic lenses, independently discovered these dark lines in the solar spectrum. He employed the telescope of a theodolite to analyze and measure the position of the lines, and so he saw them to be sharply defined dark lines.

In 1817 he published in Munich a systematic map showing no less than 578 of these lines. Although he did not use any lens to collect the rays, but caused them to pass through the prism from a slit in a window blind at a distance of about twenty-five feet from his observing telescope, the accuracy of his work has never been found at fault, and in recognition of it the solar lines are universally known by his name. He showed that they varied much in distinctness, some being thick and well marked, while others were exces-



HOW THE SPECTRUM IS PRODUCED.

sively fine. He noted the coincidence of the dark line, D, in the solar spectrum with the bright yellow lines given in the spectra of many kinds of flame.

He measured their distance from each other, and their exact position in the spectrum, and showed that it was absolutely invariable in all sunlight, whether direct or reflected from the moon or planets. On the other hand, he found, by using a cylindrical lens to lengthen the luminous point to a line, that the light of the fixed stars gave different dark lines of equal prominence, thus he thought proving these stars to be self-luminous. He also observed the difference between the light of a candle and of the electric spark. From the variety in the lines seen when different sources of illumination were used, he concluded that they did not originate in his instrument or in the earth's atmosphere.

In spite of his laborious and accurate investigations, Fraunhofer failed to recognize the full significance of the lines in the solar spectrum, although he went so far as to attribute them to some absorptive power exerted by the sun and stars.

The next step was taken in 1822 by Sir J. Herschel. When making experiments upon the color of flames he examined their spectra and found them more distinctive than the colors of the flames as seen by the eye, because in the spectrum the specific color of the material appeared as a characteristic bright band, while in the flame it was mastered by other shades. He shortly described the bright bands of the spectra he observed in the flames of strontium, copper, and potash chlorides, copper nitrate, and boracic acid. In a subsequent paper published in 1827, he said that "this method in many cases afforded a ready and neat way of detecting extremely minute quantities of many substances, which, when examined by prismatic analysis, are found to possess the peculiar rays in excess which characterize the tints of flames colored by them, so that there can be no doubt that these tints arise from the molecules of the coloring matter reduced to vapor, and in a state of violent ignition."

In 1822, the same year as Herschel's observation, Sir David Brewster turned his attention to the spectroscope, and examined the influence exerted by several vegetable juices and other colored substances on the spectrum, having, as he afterward said, as his "principal object the discovery of a general principle of chemical analysis, in which simple and compound bodies might be characterized by their action on different parts of the spectrum." He not only found that colored solutions altered the solar spectrum, but also that colored gases cut off some rays, and thus added to the number of lines in the solar spectrum, indicating the rays deficient in its light.

The next attempt to make use of the spectroscope as a method of chemical analysis was made by a distinguished worker at photography named Fox-Talbot. By a paper published in 1826 he added much to the investigations of Herschel and Brewster, and no doubt firmly laid the foundation of chemical analysis by means of spectroscopic observation. In one passage he says: "A glance at the prismatic spectrum of a flame may show it to contain substances which it would otherwise require a laborious chemical analysis to detect." The common yellow flame and striking bright bands now known to be characteristic of sodium he considered must depend on the presence of some special element, in spite of its almost universal occurrence, and its discovery considerably exercised his mind, but he came to no definite determination on the subject. He says, "The yellow rays may indicate the presence of soda, but they nevertheless frequently appear where no soda can be supposed to be present." He thus suspected that it depended on the presence of sodium, but not being able to reconcile this view with its almost universal existence in flames, he thought its prevalence could only be accounted for by attributing it to water. But then he could not account for its absence from the flame of potash salts. On another occasion, when struck with the brilliancy of these bands in red fire, he concluded that they were caused by the sulphur of the mixture burned. Thus Talbot narrowly escaped making the discovery of the sodium spectrum, which later proved a crucial point in the advance of our knowledge of spectroscopy.

Thus before the year 1830 the spectroscope had been announced as a method of detecting substances in flames by the spectra given by their light, of analyzing solutions by noting their absorptive power on the light passing through them, and had been shown to be influenced by bodies in the gaseous state.

THE INSTRUMENT.

Spectroscopes of which we now familiarly speak are somewhat complex instruments, the gradual outcome of many improvements and additions made concurrently with the advance of the science of spectroscopy.

It may be remembered that the only item really essential for the separation of the rays of white light into a play of colors is a simple prism of glass, crystal, or other transparent body, and in order to be able to see the dark lines or gaps in the solar spectrum it is only necessary that the ray of light be made very narrow to prevent overlapping of the tints.

Such a simple method as a crevice one-twentieth of an inch wide enabled Wollaston to see the chief solar lines. But for more accurate observations, greater separation of the various colored rays is essential.

In order to obtain the requisite degree of dispersion Fraunhofer viewed the beam at the distance of twenty-five feet from the prism, and at the same time he made the very important addition of an achromatic telescope with which he examined the spectrum in detail. He also used a metal plate for his slit, which was 1-40 inch wide, just half the width of that used by Wollaston.

Since the days of Sir David Brewster the slit has been so constructed that its width can be finely adjusted, and thus a pencil of light much narrower than 1-40 inch can be admitted.

This method of spreading out the colors of the spectrum by viewing it from a distance was found very inconvenient, and as the divergent rays coming from the object were refracted by the prism, a confused image was the result.

The greater the divergence of the beam and the more the dispersion in the prism, the greater must be the overlapping, and, therefore, the more indistinct would be the image. This difficulty was, however, overcome by the introduction of a converging lens into the path of the beam coming from the slit, by which means the various rays of light could be made parallel on their way to the prism. Thus a clear image of the slit is seen and a spectrum equally distinct in all its parts, or "pure," is obtained.

This very important step was made by the optician Simms in the year 1830. This achromatic lens, or collimator, is placed next the prism at the end of a tube, at the other end of which is fixed the adjustable slit.

By increasing the dispersion of the parallel rays coming from the lens, sufficient separation of the colors could be obtained without viewing the spectrum from a great distance, and with lenses of suitable magnifying power the image of the slit could be enlarged to make the details of the spectrum easily visible when the spectroscope is close to the prism.

The most essential parts of the modern spectroscope may thus be united on a convenient table so as to form a complex instrument, consisting of the following parts:

1. A slit capable of being made exceedingly fine by the approximation of its smooth metal edges.
2. A collimating lens to render the rays on their way from the slit to the prism exactly parallel.
3. A prism, or number of prisms, of as great dispersive power as possible.
4. A telescope for enlarging the minute image of the slit, and thus examining the spectrum.

For many observations a single prism does not disperse the rays enough to give a sufficiently long spectrum—*i. e.*, does not spread out the various tints so as to make the details of fine lines, etc., visible; hence it becomes necessary to use a more dispersive medium or increase the number of prisms. A great number or battery, consisting of four, six, or even fourteen prisms, may be so arranged that the light will pass symmetrically through them, and enormously increase the dispersion.

Instead of using a battery of prisms to obtain extreme dispersion by their power of refraction, the phenomenon known as diffraction may be employed to produce the requisite dispersion of the rays.

Very early in the history of optics (1665) it was noticed that the shadow of an edge of an opaque body was not perfectly sharp, even when illuminated by a point of light, but was partially lighted up at the margin by light which had apparently bent round the edge of the object. The beautiful chromatic effects observed by Schwerd in looking at the sun through a bird's feather are due to this diffraction, and a bright light viewed through the eyelashes or the meshes of a handkerchief will show similar colors, due to the same cause. These phenomena depend upon the interference of the light waves as they pass round the edge of the opaque body. If we bear in mind the fact that light consists of a series of undulations in some way comparable with the waves on water, the circumstances which give rise to interference are not difficult to follow. Just as the waves of the sea, meeting a projecting pier, are often seen to give rise to secondary systems of waves, so the waves of light, meeting an obstacle in their path, produce a similar disturbance in the ether and give rise to secondary waves. These secondary waves merging into the original waves, or with another set of secondary waves, will produce in the ether, as in water, the effect of interference. If two sets of equal waves so come together that the crest of one set coincides with the crest of the other, a wave of double size results. If, however, the crest of one set coincides with the trough of another set, *i. e.*, if their position differ by exactly half a wave length, then the one set annuls the other, and there is no wave motion. Thus, the effect which produces a calm in water gives darkness in ether.

If a narrow slit in the end of a tube be directed to a source of monochromatic light, say red, and examined through a second slit placed at the opposite end of the tube, a bright red image will be seen in the center, due to the original waves that pass straight through. On each side of this central image would be seen a dark space and then another red image, and so on, a series of dark spaces and red images fading in brightness as the distance from the central image became greater. But as red light consists of waves of greater length than the other colors, blue for instance, so the distance from the central image at which extinction and re-enforcement occur will be greater with red than with blue light, so that if the latter were employed, the blue images would be seen closer together. Thus each colored ray will have its own special angular distance at which it will be annuled and again rendered visible. If, on the other hand, compound white light be used, the various colors having different wave lengths will be differently influenced; the calm and the ripple left by the interference occurring at different distances from the central image fill up nearly all of the dark gaps seen with the red light in the exact order of their wave lengths, and thus make a perfect spectrum.

The means of applying this principle to spectroscopy is called a diffraction grating, which may be substituted for the prisms. The grating may be one of two kinds, a transparent or transmission grating, composed of glass, or a reflection grating made of brightly polished speculum metal. Upon these substances extremely fine lines are ruled, by means of a diamond point, so closely together that there are many thousands to an inch. Mr. Chapman constructed one by a machine devised by Prof. Rutherfurd, of New York, having as many as 17,280 lines to the inch, and Prof. Rowland, of Baltimore, has recently constructed some six inches in width containing 28,876 lines to the inch. These rulings act as obstacles to the light—transmitted or reflected—and generate secondary waves which by their interference produce a spectrum as above described.

The spectrum thus obtained has the advantage of having its different parts equally extended, which is not the case with refraction spectra, because, the violet end of the spectrum obtained by a prism being more refracted than the red end, the violet rays are relatively more spread out, so that the amount of space occupied by these rays is out of proportion to the relative difference of their wave length. This defect, which is termed the "irrationality" of the prismatic spectrum, is quite absent from that obtained by means of the diffraction grating, as the formation of the spectrum has been seen in the latter case to be solely dependent upon the different wave lengths of the respective rays.

Fraunhofer was the first to attempt to calculate the wave lengths of different colored lights by means of the grating, but as he only used fine wire stretched tightly between two parallel screws of fine thread, the results he arrived at were necessarily rough.

In order to determine exactly the position of any line or band in the spectrum, many methods have been employed. One of the simplest plans is to have a third tube, like the collimator, but instead of the slit, it bears at its extremity a fine scale, photographed on a glass slip, the image of which when illuminated is thrown through a lens to make the rays parallel on the surface of the prism next the telescope. The image of the scale is thus reflected through the telescope, and can be observed at the same time as the spectrum. This tube can be made to lie in the same horizontal plane, so that any line in the scale can be made to correspond exactly with a known line in the spectrum, and thus the position of any other part of the spectrum may be accurately determined.

Instead of the scale a fine wire or line of light from a slit may be moved over the spectrum, and by means of a micrometer screen the movement or distance of any point of the spectrum from any other can be read off.

In other instruments the telescope itself can be moved in the horizontal plane, and thus a fine wire across the ocular can be brought into exact coincidence with any part of the spectrum, and the position may be seen by the amount of motion of the telescope, which can be read off from a suitable scale on the stand.

Owing to the way in which the rays are turned aside from their path in the prism, the collimator and telescope must be placed at an angle one to the other. They must therefore be supported in the same horizontal plane on a massive stand. To overcome this inconvenience and enable the two tubes to be placed in the same line, so-called direct vision spectroscopes have been made. This arrangement was only possible owing to the fact that flint and crown glass differ in their refractive and dispersive powers. The less dispersive crown glass is used to bend back the slightly refractive but much dispersed ray from a flint glass prism, so that the central position of the dispersed ray comes to form a straight line with the incident ray of the collimator. Thus many convenient forms of pocket, miniature, and microspectroscopes are made which are most useful in many branches of science.

A reflecting prism was added outside the slit by Bunsen and Kirchhoff by which a constant spectrum of the sun or other light may be seen immediately below the one under examination, and thus a ready comparison may be made. By using the Fraunhofer lines as standards, the position of the new bands could be found and their coincidence accurately determined.

FLAME SPECTRA.

From the investigations already alluded to it may be gathered that when bodies are in the glowing gaseous state they show a flame with a particular shade of color, which appears in the spectrum as one or more bright bands. Owing to the constancy of their position, it was further supposed that the bands given by each substance were distinctive of it.

In order, then, to use the spectrum as a method of analysis, it became necessary to have the various substances examined in the state of heated vapor, which naturally requires a very variable degree of heat. With some bodies, such as sodium and potassium, etc., the relatively cool flame of burning spirit sufficed; others could be made glow with a mixture of coal gas and air, as used in what is familiarly known as Bunsen's burner, but in the case of the heavier metals a more intense heat was necessary. For others different kinds of blowpipes were used, and some required the great heat of the oxyhydrogen flame, and even this failed in some cases to give the requisite degree of heat. An important step was therefore made in the development of spectral analysis by the introduction of the electric spark for the purpose of volatilizing metals. Although used by Wollaston and Fraunhofer, its value as an aid in spectral analysis was not known for many years after their time.

In the year 1835 Wheatstone gave the results of an investigation in which, when examining the spectrum of various kinds of electric sparks, he found that the position of the bands varied with the kind of metal used for the electrodes. The lines characteristic of the metal becoming manifest in the spectrum, he concluded the spark was a volatilization of the metal, and not a combustion of the matter of the poles. He writes: "These differences are so obvious that one metal may easily be distinguished from another by the appearance of the spark, and we have here a mode of discriminating metallic bodies more readily than that of chemical examination, which may hereafter be employed for useful purposes." In the plate accompanying his work the characteristic lines of the sparks of many metals and of the sodium flame are clearly indicated.

The first map showing the bright bands characteristic of different substances in the glowing state was made in 1845 by the well-known chemist, W. A. Miller. He examined the flames of the alkaline earths, and made some interesting additions to the knowledge on the subject; but as flames luminous with other substances were used, the drawings are not sufficiently characteristic to be regarded as distinctive tests.

In 1853, Angstrom, the distinguished Swedish philosopher, who has added so many original facts and so much accurate knowledge to this subject, published a paper on optical researches in which he foreshadowed many of the conclusions which a few years later made a complete change in the science of spectroscopy. He showed that "the spectrum of electric sparks must really be regarded as consisting of two distinct spectra; one of which belongs to the gas through which the spark passes, and the other to the incandescent metallic particles from the electrodes."

He stated his belief in the distinctiveness of the bright bands seen in the spectrum of flames, which he considered characteristic of the chemical substances in the flames.

In 1857, Swan, while examining the spectrum of the flames of the hydrocarbons, came to the conclusion that the yellow light so difficult to exclude from flames and the bright bands so constant in the orange part of their spectrum depended on the presence of sodium salts, which existed in everything examined. He says: "When, indeed, we consider the almost universal diffusion of the salts of sodium and the remarkable energy with which they produce yellow light, it seems highly probable that the yellow line which appears in the spectra of almost all flames is in every case due to the presence of minute quantities of sodium."

Swan further made a valuable contribution toward the solution of the question as to whether the bright lines of a glowing gas are solely dependent on its chemical constituents, and he showed that by raising the temperature with the blowpipe lines could be made to appear which were not distinguishable in the ordinary flames of the substance.

It was soon recognized that the great value of this mode of detecting chemical elements, etc., lay in its great delicacy, quantities of matter which were unrecognizable by ordinary chemical analysis being easily detected by the spectrum of its flame. Thus one millionth of a grain of lithium, strontium, and calcium can be recognized easily in the colorless flame of coal gas mixed with air, while the delicacy with sodium is so great that even the amount in the dust of the atmosphere can be seen to give a yellow color to this flame and a distinct and very characteristic band.

The foregoing observers may be said to have laid the foundation of the new mode of chemical analysis, but it remained for subsequent observers to perfect the methods, and by its means make more important discoveries.

In spite of the admirable generalization of Angstrom the various discoveries in connection with this subject remained as isolated facts until the work of Bunsen and Kirchhoff made a new epoch in the applications of spectral analysis. Not only did they place beyond doubt the special spectra of the alkaline earths, but they also greatly improved the methods previously in use, and they introduced a new plan of mapping out the spectra so as to render their differentiation more ready and complete.

Bunsen, while examining the alkalies in a mineral water, found some bright lines which he had never met with before in the spectrum. He evaporated very large quantities of the water and succeeded not only in detecting and separating two new elementary bodies, but also in finding out the properties of several of their compounds. These elements, which he called *rubidium* and *cæsium*, from the peculiar colored bands of their spectra, are so like potassium as to be distinguished with great difficulty from it without the aid of the spectroscope.

Shortly after (1861) the discovery of rubidium and cæsium by Bunsen, Crookes discovered that a peculiar single pale green band was given by the green flame of a compound he had under examination, and he showed that this band was caused by the presence of a new elementary substance which he called *thallium*. This body, which has since been found in large quantities in certain varieties of iron pyrites, used in making sulphuric acid, possesses some remarkable chemical properties, taking as it does a somewhat anomalous position between the alkalies and the metal lead.

Two years later, 1864, another elementary body was discovered by two professors of the mining school of Freiberg, by means of the two indigo-colored lines seen in its spectrum, whence it received the name *indium*.

In 1876 yet another elementary body was found in France by the use of the spectroscope. This was the discovery of *gallium* by M. Lecocq Boisbaudran.

The general result of the examination of the various chemical elements in the condition of glowing vapor is that their spectra consist of colored lines or bands with more or less wide intervening spaces. The position of these bands is invariable under all circumstances, a fact which, though implied by many observers, was first vigorously insisted upon by Bunsen and Kirchhoff in 1859. But the number and character of the bands are not so constant, but are found to vary with the temperature and pressure of the vapor. As a rule, the higher the temperature and pressure, the brighter and wider do the bands become. With very high temperature many additional bands may appear. Thus the sodium spectrum gives in the spirit lamp the well known double yellow line, but with higher temperature several other lines appear, and with extremely high temperature associated with high pressure these so increase in breadth and number that the spectrum looks almost continuous. Plucker and Hittorf obtained similar results with the spectra of luminous gases. By varying the pressure of hydrogen, changes take place in the number and character of its bands, and with a maximum pressure the spectrum becomes continuous. It must then be remembered that although spectra with bright bands on a dark ground are characteristic of glowing vapors, under extreme pressure the spectra of bodies in this state may appear to be continuous.

Care must be taken in working with very minute quanta to use the degree of heat best suited for the substance under consideration. Bunsen and Kirchhoff soon found that the delicacy of the spectrum as a test for the presence of the alkalies and alkaline earths increased as the temperature was raised to a certain point. Cappel has shown that for the spectral analysis of alkalies the oxyhydrogen flame gives the most accurate results, but that for metals the electric spark is much more delicate.

ANALYSIS OF LIQUIDS.

So much for the information to be gained from colored flames and by the bright bands, indicative of the presence of substances in the condition of glowing vapor.

Let us now turn to the other kind of spectra in which dark lines or bands are observed, and see how far these absorptive spectra can help in chemical analysis.

The facts concerning the absorption of various rays of light by colored solids and liquids were known before the days of spectral analysis, so it was not surprising that the prism was used to examine colored solutions.

No coloring matter has as yet been found which will absorb or transmit only one kind of colored ray. The colors of transparent solids and liquids, therefore, as seen by white light, are mixed colors, and their absorption varies according to the refrangibility of the light which falls on them and the degree of concentration of the solution.

Brewster was the first to examine colored solutions. He investigated both inorganic, such as cobalt and chromium salts, and organic substances, viz., alkanet roots, cochineal, litmus, chica, and cudbear.

In order to examine solutions of chemical materials it is only necessary to bring a requisite thickness of the liquid in the path of the beam on its way to the prism. In this way it has been found in a great number of cases that a distinctly selective absorption occurs, that is to say, in addition to the dark lines of the solar spectrum, other dark bands are seen, indicating that corresponding rays have been cut off. These bands can be best seen when white light giving a continuous spectrum is used.

Not only in the inorganic world, but also in organic substances, whose detection offers so much difficulty to the chemist, the spectroscope recognizes many bodies in the smallest quantities in a complex mixture.

It was shown in 1867 by Askenay that the green coloring matter of plants (chlorophyl) can thus be recognized by one very dark band in the red part of the spectrum, with three fainter bands in the orange, yellow, and green, while the blue shades take a faint red hue. This green solution, therefore, absorbs only certain rays of peculiar wave length or refrangibility, while it transmits all other colors of white light.

In the same way the brilliant red coloring matter of

the blood (oxyhæmoglobin) shows two distinctive dark bands in the yellow and commencement of the green, while the blue and violet ends of the spectrum are nearly extinguished. These bands, which are characteristic of arterial blood, were first pointed out by Hoppe-Seyler in 1863.

In the year 1864 Stokes, of Cambridge, now President of the Royal Society, investigated the spectrum of blood, and found that when its oxygen was removed the double bands were replaced by a single one, which occupied a little more than the space existing between the double band.

When the coloring matter of blood is united with carbolic oxide, as occurs in poisoning from charcoal fumes, it acquires a new and distinctive spectrum, which has been suggested for use in medico-legal purposes.

Sorley has applied the spectroscope to the detection of adulteration, and, devoting himself to articles of commerce, has shown how delicate this means of determining small quantities of many substances in mixture can be made by microspectroscopy.

(*To be continued.*)

PLANTS USEFUL YET DANGEROUS TO MAN.

By Mrs. N. Pike.

How true it is that through all plant life our "bane and antidote" lie near together, if we only knew how to seek them. How few there are of even the most dangerous plants that have not some useful properties when brought under the expert eyes and fingers of the chemist. Chemistry and kindred sciences have eliminated tinctures so valuable that many a suffering human being has by their means been snatched from the very jaws of death. On the other hand, to satisfy the worst passions of our nature, hatred, jealousy, and revenge, these same plants have been forced by bad men to yield essences so deadly, when skillfully applied, that mind and body, or both, give way under them, and leave either a wreck with mind unstrung and crippled for life or death in the midst of life occurs.

I will speak first of the thorn apple or *Datura stramonium.* It grows wild in waste places in North America, and a curious fact is that the seeds will remain buried deeply in the earth for years, but if the place is burnt over, the Datura springs up through the ashes of the burnt plants. It is a native of Africa and the eastern islands and of Asia. Every one knows the plant with its handsome, bell shaped, white flower and its heavy narcotic scent, and the large seed vessel covered with spines. The whole plant is poisonous, and I know of none more abused to evil purposes than it.

Some East Indian species are said to cause faintness even from inhaling the odor of the flowers. Preparations from the Datura are in constant use among many of the tribes of Hindostan to get rid of or punish their enemies, slowly or rapidly, as the case requires. Even a few seeds ground up and put in food cause delirium, often serious illness, if not death. Of course, the action of all poisons is intensified in hot climates. In some cases the plant is bruised and the leaves thrown about where they can be trodden on with the bare feet.

I know of a case where a young, well-to-do Indian from Bombay was courting a colored French Creole girl. Now, as Creoles look down on Indians and call them *les negres,* though many shades lighter than themselves, when Berisammy asked the mother for her girl she was furious, and beat her unmercifully. Soon after the old woman's feet and legs began to swell, and she sent for a doctor, telling him that Berisammy had thrown stramonium round where she had been walking and the poison had entered her bare feet. How true the accusation was I know not, but the woman was laid up for weeks, and every Creole near believed in the poisoning. To quote another instance that came under my own observation. A Frenchwoman in Mauritius believed her husband unfaithful, and as the lower classes there are noted for superstitions of all kinds, fortune telling, charms, etc., she resorted to one of the women whose sole business was preparing potions for diseases of mind and body. The woman gave her applicant a love potion she guaranteed would make her husband faithful for life. It nearly did so, literally, for after taking it he became delirious, and so ill that in her fright she sent for a doctor, who had great difficulty in saving his patient. The woman confessed what she had done, and when the remaining potions were analyzed, the principal ingredient was found to be stramonium.

In very early times this plant was used in pagan countries, and the wild ravings of priests and priestesses were supposed to proceed from infusions of it, and their incoherent sentences the inspirations of the gods. Their communications with the dead and prophecies were the effects of this terrible poison. Many a one has lost his or her life from carelessness in the concoction of the draught, and it was accounted for to the populace that the sibyl was so filled with the divine spirit that the earthly form had to succumb.

Though the poisonous properties are stronger in India, yet they are quite sufficiently so here in America. I knew of a boy who ate some of the seeds, and the whole lower part of the body became paralyzed, and it was with difficulty they saved him from death, but he was a cripple ever after.

There is a brighter side even to the Datura, and this much abused plant, with all its venom, if properly manipulated, has healing and health giving properties. I once had a severe fall from a horse, and one knee was so badly bruised I was lame a long time. An old Hottentot woman, seeing how I was suffering, offered to help me. She brought some stramonium leaves and held them over the fire till the stiffness was out of them and they were damp from the juices drawn out by the heat. She then placed them round my knee, and, I must say, the first application drew the flesh and hurt considerably. As fast as they were dry she laid on fresh ones, and by the time she got through I could put my foot to the ground. I never saw a Hottentot who had not a herb remedy for every ill that flesh is heir to.

In China a decoction of the leaves is used in cases of hydrophobia, and the homeopathists use it for convulsions in the same terrible disease, in asthmas, and numerous other complaints, and allopathists as an anodyne and antispasmodic.

Few who have hunted for botanical specimens over waste places have escaped entirely the sharp stings of the nettles, *Urticadioica* and *Ureus,* caused by the rough leaves being covered with minute tubular hairs, which, when pressed, give out their venom. The parts stung often inflame severely if it is hot weather or the blood out of order. A species growing in India has very serious effects when the plant is accidentally gathered, and one in the island of Timoo goes by the name of daoum setan, or devil's leaf, from the virulence of the poison issuing from the glandular hairs. In former times, when India was under the rule of the savage native chiefs, nettles were constantly used as a terrible means of punishment for both men and women. They were often beaten with them, and even their whole bodies covered with them and exposed to a burning sun to extort money or a confession of imaginary crimes from the wretched victims.

In spite of its stinging properties the common nettle is used in the British Isles and in France in decoctions as a purifier of the blood, and the young shoots are used as greens or spinach. The tincture of *Urtica ureus* ought to be in every household as a remedy against stings of wasps, bees, ants, and mosquitoes. It is a sure cure if properly administered for the inflammation consequent on their bites or stings. When collecting marine plants and shells in the shallow waters within the reefs of the islands of the Indian Ocean, I always carried a solution of the tincture with me, as holothuric and other creatures abound covered with hairs like a nettle, but it always allayed the irritation at once. On one occasion my wrist and hand were badly bitten by a swarm of red ants I disturbed, and it seemed as if red hot needles were pricking me, but a lotion of *Urtica* stopped the burning pain.

women are fairly raging, and it takes days to recover, and even then they are sullen and stupid.

Another tree, the cocoanut, one of the blessings to the inhabitants of hot countries, especially to the South Sea Islanders, who look at you with surprise when you tell them it does not grow north, and wonder how you can live without it, as it furnishes them with most of the necessaries of their life. Early morning as you pass a tope of cocoanut trees you see several tin cans with a cloth around them hanging under the crown. These were placed there the night before, when Indians scale the tall trees with a thong of leather fastened to each ankle, about a foot apart, and thus climb very rapidly. Soon after daylight the men go round the city with large baskets on their heads filled with *cocoa tendre,* or young cocoanuts before the fruit is formed, and little bottles of the juice drawn from the tree.

This is a pleasant drink on a sultry day, but other bottles are kept to ferment, and the harmless liquor becomes arrack. This makes the men loud and quarrelsome, and often when women join in the drinking it ends in their being severely beaten by their jealous husbands.

I will now speak of two well known plants that are sufficiently dangerous in themselves without the aid of man's villainy to exaggerate the risk. I mean the two species of *Rhus,* the *R. toxicodendron,* or poison ivy, and the *R. venenosa,* or poison sumac. No two plants have been more anathematized than these, and it is scarcely to be wondered at. It is a curious fact that all persons are not equally susceptible to their influence. Even in the same family one or two may be affected and the others enjoy complete immunity.

POISON IVY—RHUS TOXICODENDRON (L.)

To show how valuable even nettles are, I will mention one found in the Neilgherry Hills, in India. Its fiber is said to be worth £200 a ton in England, but the plant has to be boiled to deprive it of its stinging qualities before using.

In the next order to the nettles we find a plant invaluable to man all the world over—namely, the hemp or *Cannabis.* I need not enlarge upon the uses of its fibers for cordage, sailcloth, sacking, or hemp seed for birds, and an oil that serves many purposes in commerce. Man is, however, not satisfied to use it, but must abuse it to gratify that most degrading of passions, the love of stimulants that intoxicate. *Gunjah* is prepared by the Indians from the herb and its peculiar resins, and after the first stimulating effect has passed it affects mind and body. A state of raging excitement follows, till a very pandemonium reigns and horrible murders and crimes frequently ensue from its use. There are strict laws against gunjah being sold, but they are constantly evaded.

In Arabia and Turkey, the well known *haschish* is made from hemp, and in Cairo the product goes by the name of *mapouchari.* It is used for intoxication on the west coast of Africa, where it is called *diamba.* One of the species grows in South Africa, and a preparation is made from it by the Hottentots for smoking, called *dacha.* It has much the same effect as the Indian gunjah, and it and honey beer are not allowed to be used by the men working for respectable farmers. The latter is even worse than the dacha, though it would hardly be supposed that so simple a product as honey could be so perverted. Fresh honey is taken and fermented for some days, and a general invitation goes out to all the neighboring Hottentot farm hands. Dacha is passed round, and the first effects of the beer are only exhilarating and produce a noisy chatter, but later on—for the whole tub must be emptied, as it will not keep—the wildest orgies follow. Both men and

Fortunately, hitherto, I am one of the favored, as I often handled the poison ivy before I knew much of the American flora, but always unhurt.

I give a sketch of this plant, that others as ignorant as I was may know it on sight, as it is the commoner of the two, and may be seen climbing over post and rail fences or creeping along the ground the country over.

Many people cannot even approach the Rhus in hot weather, as it appears to exhale a noxious vapor, particularly where it grows out of the sun.

One case in point was that of a friend who was so badly affected by the poison ivy that he was confined to his room some days under a doctor's care. His eyes were closed and the face terribly swollen, yet he says he was not within some feet of the plant while hunting for insects.

I will take a few facts relative to the Rhus from one of Colonel Pike's note books, which may be of interest. He says: "A friend and myself were out in the fall of the year gathering plants, when we were attracted by some drupes of pretty berries, which we gathered fearlessly, and they were placed with other things and brought home. In the night I awoke with sharp itchings of the hands, face, and other parts of the body. I at once arose, as I knew then I was suffering from Rhus poisoning. I had studied the matter, as I was aware I was likely at any time to be affected from constantly working and collecting in the woods. I made a strong solution of hypersulphate of soda with boiling water, and with the liquid as hot as I could bear it sponged all the parts affected. I felt immediate relief, as it in a measure checked the spread of the poison, but it was many days before I completely recovered. My friend was less fortunate, and was laid up for a long time, a sight to behold. I discovered one important fact that should be known to every one. I had often handled the leaves of this tree with impunity before this time. nd as a strong alkali was a cure, I came to the con-

clusion that the blood in a person must be acid for him to be affected. I saw a man put some leaves in his mouth and crush them on his face harmlessly. After careful examination of the man and tests with litmus paper, I could not find a trace of acid in his blood or on his tongue. I continued my investigations, and found out of six individuals whose blood was neutral none was affected, so that the blood must be more or less acid for the venom to act."

There was proof of this fact in the case recorded above. The berries the colonel brought home were new to me, and the silvery glaze on them looked so pretty that I sat down and sketched them, holding them in my hands and examining them closely with a lens. I then tied the bunch and hung it up, thinking I had found a new treasure. When the colonel threw them next day in the fire, I was surprised to find I had been handling the *R. venenosa*, as I felt no effects from it. As every one knows the evil qualities of the Rhus, I must say one good word for it. Homeopathists consider the tincture a valuable remedy in rheumatism, paralysis, eruptions, etc.

STANLEY'S EXPEDITION.

SCARCELY a year ago, Stanley emerged at the junction of the Congo and the Arrouhouimi, gave a stirring narrative of the first part of his voyage in that concise and picturesque style of which he is master, and then plunged anew into the impenetrable darkness of that virgin forest whose tropical splendor and deadly magnificence he was the first to describe to us.

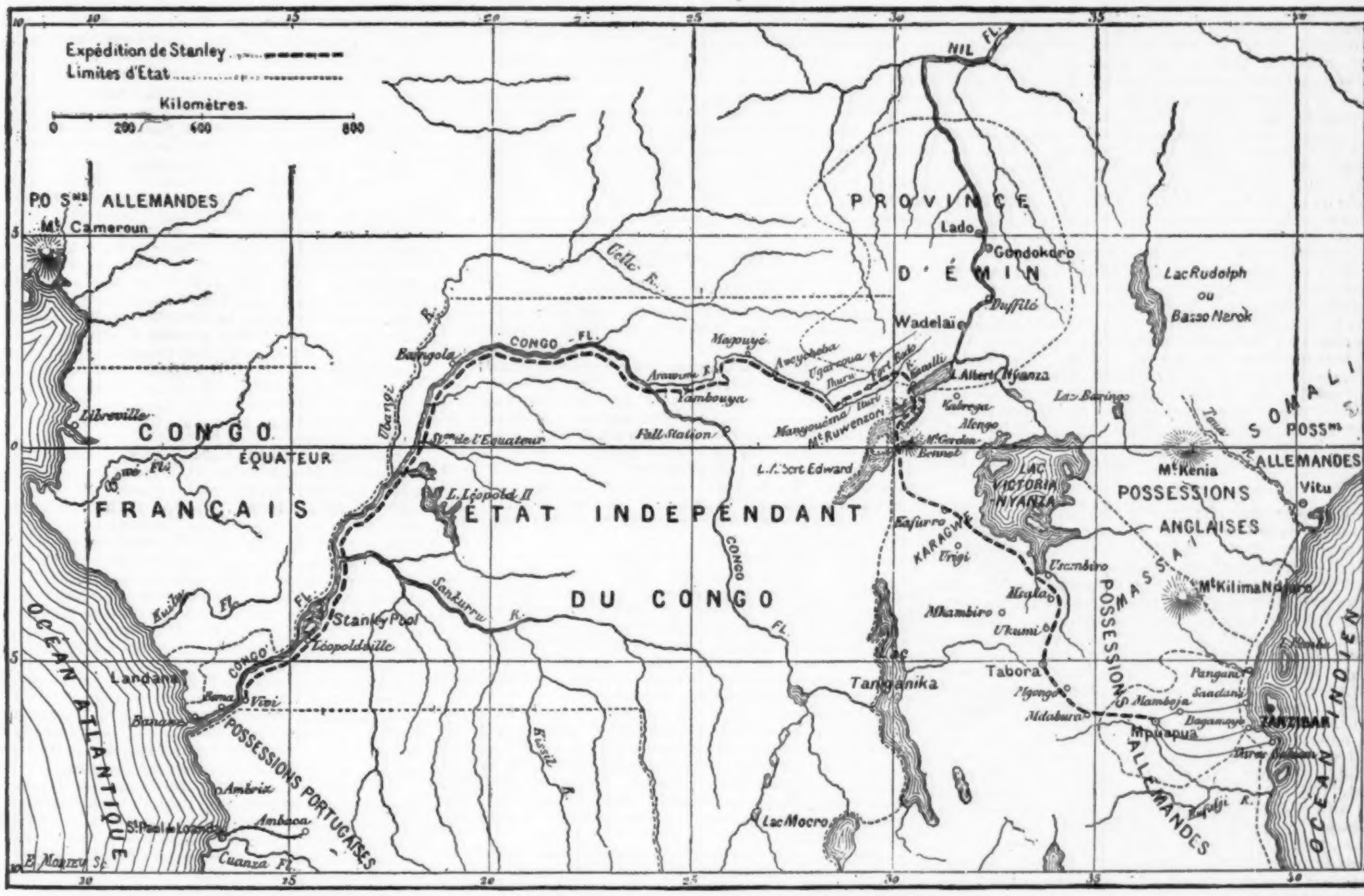
Until then, eleven months had passed without anything reaching us save the echo of confused rumors transmitted from tribe to tribe, from the banks of the starting point on the shores of the Atlantic, ascending the Congo, following the Arrouhouimi by cutting a passageway with axes through a primitive forest, suffering from hunger, thirst, and poisonous emanations from a tropical swamp, rejoining Emin, starting out again in search of the rear guard left by Major Barttelot's orders at the confluence of the two rivers, to find this reserve disorganized by the death of its chief, taking for the third time the Ituri route, full of ambushes and strewed with corpses, reaching the central plateau only to learn of the revolt of Emin's soldiers and the arrest of the pasha and the officer left with him, negotiating with infinite patience and ability for the freedom of the captives and the departure of the entire caravan for the east coast of Africa, presiding over the continuously obstructed march of troops of whom half were glancing with regret toward Wadelai and the easy life of the equatorial provinces—such has been Stanley's itinerary for the last two years. As compared with this wonderful campaign, the retreat of the ten thousand, immortalized by Xenophon's elegant pen, was but child's play, and it would require an inspired pen to trace this African epic worthily.

Such things, it is true, can be well described only by those who have accomplished them, and we are glad to learn that Stanley himself will write the history of his expedition. The English publisher who offered him two hundred thousand dollars for the manuscript of the book knew what he was about, and certainly concluded no foolish bargain. We scarcely believe that there is anything true in the rumor according to which the committee that bore the expenses of the expedition pretended to have the right, not only to the heroic services of the little band of which Stanley is

With Stanley, we have proved that the ancients, those sagacious observers, whose so many accurate descriptions our ignorance has relegated to the rank of mythical inventions, were acquainted with these formidable pygmies, whose cunning and violence compensate for the smallness of their stature. With him, we have had to contend, now with the open hostility of these stunted beings and now with their dishonesty. We have seen the chief of the expedition, acting under the inspiration of the necessities of the public safety, capture these gnomes, in order to use them as guides, and punish them severely for their lies and obstinacy.

The public, which loves what is living and picturesque, has seized upon these details with avidity, and has, perhaps, too greatly neglected the scientific part of the report. Doubtless the results are as yet imperfectly known; still, it is not impossible to give a general idea of them. They may be classed under two principal heads: (1) that which concerns the region of the Arrouhouimi and Ituri, and (2) that which concerns the route that starts from the Albert Nyanza and prolongs itself between the two other great lakes—the Victoria Nyanza and the lake formerly known under the name of Muta N'zige, but hereafter to be called the Albert Edward Nyanza.

From Yambuza to Kavalli, in the first of these two regions Mr. Stanley's discoveries do not add very greatly to our knowledge of the country. It is in the second part of his itinerary that he has made the most notable discoveries. Lake Albert Edward is found to have a much smaller area than that attributed to it under its name of Muta N'zige. The Victoria Nyanza, on the contrary, acquires a vast new sheet of water toward the southwest. The distance of the three lakes is found to be considerably diminished.



MAP OF EQUATORIAL AFRICA—ROUTE FOLLOWED BY STANLEY IN HIS EXPEDITION IN SEARCH OF EMIN PASHA.

great lakes to the shores of the Red Sea, and of which, according to General Grenfell and the defenders of Suakim, Osman Digma made himself the interpreter. The deplorable events that were occurring on the coast of Zanzibar, the slow progress and the bloody conflicts of Major Wissmann, the sad fate of the expedition so imprudently conducted by Dr. Peter, the scraps of news that represented the missionaries—Catholic and Protestant, English and French—struggling in the region of the Nyanzas with a rising tide of fanaticism and barbarism—all this justified the worst apprehensions on the subject of the heroic adventurer and his companions in arms.

All at once, a dispatch came to joyfully surprise us: Stanley's runners were at Mpuapua, at a few days' distance from the coast, and Stanley himself, with nearly his entire staff, followed by Emin and Casati, was forming a junction with Wissmann's troops. Thus is finished under our eyes one of the most remarkable enterprises that has taken place in a century fertile in wonders. Stanley has accomplished the mission that he undertook, and which was one that appeared to many persons to be beyond human power. He has once more proved that he is truly in possession of the talisman that his faithful Zanzibarians ascribe to him. In this melancholy twilight of our closing century, while the most valiant are distrusting themselves, their cause, and the grandeur of our race, there is something ennobling and strengthening in the spectacle of this journalist (this calm, spare, and nervous man, whose hair seems to have become gray only to diffuse over his entire person the cold tint of the well tempered steel that he is made of) calmly offering the boldest challenges to the genius of a desolate continent, and reappearing after mastering the elements, man, and even fortune itself.

Leaving a well earned repose, landing at Zanzibar in order to form a caravan from the experienced veterans of his preceding expeditions, then, after selecting a chief, but also to some priority over the copy brought from Africa, at the cost of some suffering, and written, it may be said without much exaggeration, with the blood of the adventurers. For us, who are fortunately not condemned to the use of the system of division, it is possible, without wandering off into the mass of details that the daily press has made known to everybody, to give in a succinct form the principal results of the voyage. We shall not dwell at too great a length upon the purely picturesque side of it. After once having read them we could not forget those powerful descriptions of the virgin forests of the Arrouhouimi and Ituri—that exuberant vegetation that forms over the head of the traveler a thick dome almost impenetrable to the rays of the sun and to vivifying puffs of air, and which spreads out under his feet a soft carpet made of the detritus of ages, and wherein arise deadly emanations. We imagine that we see the unfortunate natives, emaciated, consumed with fever, covered with ulcers, and incapable of taking another step, imploring their companions to make away with them, and stretching themselves out upon the mossy earth in which the sole impress of their body seems to dig the tomb which is to close over them. We are haunted by this tragic picture of a halt in the open forest, while a detachment sent in search of necessary food prolongs its absence, and the faithful Zanzibarians, without complaint, without murmur, lie down one after another, to sleep their last sleep, while their distracted chief knows not whether to continue to wait or to plunge at hazard into the thicket.

It seems that, upon the discovery of fields of plantain and sorghum, the famished band settled like a swarm of locusts upon the succulent plants—the provident making provision for a future day of want, and the improvident eating until they became sick, without putting anything aside for the future.

We have seen those dwarf savages whose populous tribes inhabit the forests of the banks of the Ituri.

In the eternally snow-clad majestic summits of the Ruwenzori, Stanley has found a new and more imposing edition than the others of those Mountains of the Moon whose existence in Africa has long been revealed in vague legends. If we are to accept Stanley's estimations, which are perhaps optimistic, the climate of this central plateau is delicious and is tempered by cool winds, and the country is adapted to play in the development of Africa's destiny the role of *sanatorium*, indispensable in these tropical latitudes. In addition, Stanley appears to have recognized the existence and course of new affluents of the Nile.

We have purposely relegated to the last part of this article the discussion of the political aspect of Stanley's expedition and its relations with Emin. In order to prevent a misunderstanding it was necessary to render full homage to the value, merit, and illustrious personality of the great traveler before touching on this phase of our subject.

The more we are disposed, for our part, to salute with sympathy the man who has been able to renew upon a vaster scale the exploits of the *conquistadores* of the 16th century, and who has given to our skeptical and pessimistic generation the beneficent spectacle of an invincible will in the service of a disinterested cause, the more we feel ourselves free to criticise the practical effects of this great effort. There is no need of reading between the lines of the report to see that a profound divergence of views separates Stanley and Emin.

The latter, compelled and forced, left with regret, and in spite of himself, the provinces that he had governed for more than thirteen years. Placed at this post of honor and danger by Gordon, he thought it possible to address an appeal to Europe, not to be relieved from duty and brought back in the baggage wagons of an expedition, but for the aid that he judged indispensable for keeping up his situation. When he wrote to Doctors Junker, Felkin and Schweinfurth, he

solicited an intervention that should put it in his power, not to desert equatorial Africa, but to defend his authority and perhaps to reconquer all or a part of the Soudan. Stanley did not hear with such an ear.

When, at the end of 1888, Stanley returned from his point in the camp of Barttelot, weary, feeble, and enervated, he maintained that Emin should consider himself released from all obligation toward his troops by the revolt of which he had been the victim. Emin, with a little of German sentimentality that he owes to the Schnitzler blood that flows in his veins, and with much of the noble stoicism of the captain who wishes to be the last to abandon his ship, dilly-dallied, contradicted himself, renewed the day after the promise of the day before, and in reality did not wish to leave if it were possible to stay; at all events, he wished to take all his people with him, from the daughter that he had in the Soudan by an unknown mother up to the last of the slaves of the last of the Egyptian effendis under his orders.

Stanley, clear headed and resolute, who has reduced for himself all the *impedimenta* of sensibility, and who does not willingly suffer obstacles, especially on the part of another's will, shrugged his shoulders and intimated that Dr. Schnitzler was afflicted with that peculiar form of folly which he called the Soudanese mania, and of which, according to him, Gordon was one of the most illustrious victims; and he went on with his preparations.

In order to appreciate what there was of just and noble in the hesitations of Emin, it suffices to remember the heroic Gordon shut up in Khartoum and writing in the journal which is the incomparable legacy of his last days an indignant protest, superlatively ironical and eloquent, against the idea suggested to him by the British agent at Cairo, of buying his safety through the abandoning of the Egyptian garrisons. And in the present case it was not solely a question of leaving soldiers behind him. It was the last remains of the civilizing work in the Soudan that it was necessary to overturn with his own hands. So long as the equatorial provinces, those regions in which Gordon inaugurated his beneficent reign upon a more modest scale in the Soudan, remained in the hands of an Emin, mahdism had not penetrated everywhere. There remained one strong hold of civilization in the very heart of Africa, and it was always possible to seize the mahdist bands unawares and crush fanaticism anew in its nest. This was the mental reservation that had dictated to Emin his appeals to Europe. He saw himself resupplied with provisions and ammunition, and relieved, and not only placed firmly in the saddle in his government, but capable of running down the enemy which was menacing Egypt and holding the Soudan.

So it is in Stanley's narrative that we must read of the surprise and disenchantment that possessed him when he learned what was desired of him. The Egyptians, who saw their chief irresolute, who dreaded a change of residence, and who had but little faith in Stanleys' mission, soon lost respect for and obedience to the governor, and deposed and imprisoned him. Whatever resolutions Emin may have made for the future, it was all up with his authority, and, consequently, with his usefulness.

* * * * * * *

Emin, however, was not exactly the first comer. He took his degrees in the school of lofty soaring adventurers, just as Stanley himself did. By turns the physician and confidant of an Ottoman pasha, then the husband of a rich and mature Osmanli beauty, an itinerant naturalist in Africa, then a physician to Gordon, who did not believe much in medicine and the profession of it, next lieutenant of the viceroy of Khartoum, then governor of the equatorial provinces, he was able, after the defeat of Hicks Pasha had shaken the Egyptian domination and Gordon's disaster had destroyed it, to maintain these vast regions under his authority, which was after all purely moral. While his old colleagues, Lupton and Slatin, fell into the power of the Mahdi and had to buy from the mission of the false prophet the right to spend the rest of a miserable life in chains, Emin, up to the arrival of Stanley, opposed a firm rampart toward the south to the progress of fanaticism. To-day, the bulwark is destroyed. Omar Saleh, the sheik who figures with so little honor in Gordon's journal, had trouble in conquering even the lieutenants who revolted against the Austrian pasha.

We here see the bond that connects with reality the fantastic stories told by Osman Digma to General Grenfell upon the march, and the battles of the white pasha in the Bhar-el-Gazelle. The Mahdists advance, intoxicated with their victories, and especially with the miracles by which Allah had confirmed the mission of their prophet, that is to say, the green sun that was to exhibit its sinister brightness in the heavens before the manifestation of such or such an envoy from God, and which the dust from the eruption of Krakatoa made appear at the desired moment, and those aigrets of fire which sparkled at the point of the arms of the true believers, and in which European science sees a phenomena analogous to that of St. Elmo's fire.

As regards this march, the civilized world will ask whether it was indeed worth the while to run so many risks, to undergo so many fatigues, to spend so much money, to end so many lives, to strew the dark forest footpaths of the Ituri with so many corpses, in order finally to efface the last vestige of Gordon's empire. Assuredly, it is something to say: The man is saved, Emin is alive. But it is hard to have to add: The work is destroyed, the entire Soudan remains Mahdist. Nothing will be able to compensate for that misfortune.

It is thought that Stanley will not return at once to Europe. Instead of going to enjoy a well earned rest, it will be a question for him to accept, at Mombrassa, in the territory submitted to English influence, duties analogous to those of Major Wissmann from Bagamoyo to Mpuapua. Invested with the authority of British commissioner, Stanley would have the founding of the English domination in these regions upon solid and extensive bases, and of putting German pretensions slightly in the shade.

Between a Stanley and a Wissmann the disproportion would be glaring.

It is to be regretted that, from the standpoint of humanity, there is no great difference between Stanley, who has never professed an inviolable respect for the life and liberty of the natives, and the German major, who has all the brutality that his compatriots are ever ready to use toward conquered populations. Politically, such an enlistment, even provisional, in the service of the British Society of East Africa would be a very great affair and of much consequence. It would remain to be seen whether Stanley would consent to play the role of conqueror for Sir William Mackinnon and his colleagues, and whether he would succeed in checkmating the greedy and ill-advised ambition of the Germans.

While professing a more than limited sympathy for the enterprises of Germany, we will be excused as a Frenchman for feeling some inquietude on the subject of the insatiate appetite of England, which, *vide* a recent article in the *Times*, has its eye upon nearly the whole of the Dark Continent, and has the pretension to weave a compact and uninterrupted network of British possessions from the Delta to the Cape.

There is room for everybody in Africa, even for the Africans, and it would be degrading for a man like Stanley to make himself the instrument of a plan of conquest instead of continuing to serve science and humanity solely.—*F. D. Pressense, in L'Illustration.*

To conclude, we give a few biographical notes concerning Stanley:

John Rowland, better known under the name of Henry Moreton Stanley, is, as says the *Saturday Review*, the Napoleon of the special correspondents of American journals and of the explorers of Africa. He was born at Denbigh, in Wales, in 1840. After a youth spent in poverty, he succeeded in obtaining a position as a reporter on the New York *Herald*, and made his first exploits in Abyssinia in 1867, in following the English expedition led by Lord Napier. The circumstances under which he was unexpectedly ordered by Mr. James Gordon Bennett, in 1870, to go to the center of Africa in search of Livingstone, whose fate was then greatly attracting the attention of the Anglo-Saxon world, are well known. On the 3d of November, 1871, Stanley met with the illustrious missionary at Ujiji, on the banks of Lake Tanganyika.

In 1875, the New York *Herald* and the *Daily Telegraph* commissioned him at their joint expense to traverse Africa from east to west. The discovery of the Upper Congo was the fruit of these three years of travel. Stanley has since then served the King of the Belgians in the new state. Three years ago he started for the relief of Emin. He may be truly called the king of travelers. He has, it would seem, a charm, a magic amulet, which preserves him from the dangers to which his rivals would easily succumb.—*F. De P.*

EARTH TREMORS.

By Herbert A. Howe.*

During the month of October, last year, some experiments were made at University Park, a suburb of Denver, to determine the effect of vibrations of the earth caused by trains, teams, and men, on images reflected from a mercurial horizon. The reflected images of objects on the roofs of houses were watched with the naked eye, and also through the telescope of an engineer's transit made by Fauth & Co.; the magnifying power of the latter was about twenty diameters. The observing station was 1,500 feet away from the Denver, Texas, and Gulf railroad, and 500 feet from the Denver and Santa Fe (narrow gauge). The soil is a loam several feet deep, and was very dry, the surface being quite hard.

Below is a summary of the results.

1. When a man weighing 135 pounds jumped up from the ground six inches, and came down on his heels, the reflected image quivered, if the man was not more than 125 feet from the mercurial horizon.

2. A team of small horses attached to a light wagon, and driven at a slow trot, caused disturbances which vanished when the vehicle reached a distance of two hundred feet from the mercury.

3. A pebble half as large as one's thumb, dropped one-eighth of an inch at a distance of one foot, made the reflected image tremble perceptibly to the naked eye. When the pebble was dropped similarly and repeatedly on a little heap of loose earth, no vibration was detected until the earth became packed. The image seemed to leap *away* from the point where the pebble struck.

4. Denver and Santa Fe trains did not shake the image, probably because they ran slowly in approaching the depot.

5. Passenger trains on the Denver, Texas, and Gulf made more marked tremors than freight trains of much greater weight. Though the amplitude of vibration of the image was not great, it was seen to increase as the trains approached and to die away as they receded.

6. The horizon was placed on the ground at the bottom of a rectangular excavation six feet deep, sixteen feet long, and two feet eight inches wide, which was surrounded by a twelve inch stone wall. The transit was above, its tripod resting on the natural surface, and the reflected image was that of the cornice of a house. Pebbles of various weights were dropped repeatedly a distance of three feet, striking on the natural surface near the instrument. The point of striking was eight and a half feet from the mercury [six feet horizontally and the same distance vertically]. Some of the pebbles caused no tremor that could be seen, others a slight one, and the heavier ones a very marked quivering.

The horizon was then placed on the natural surface at a distance of eight and a half feet from the point where the pebbles struck the ground. The same pebbles were again dropped from the same height, but no *shaking of the image could be perceived.* When, however, they were dropped at a distance of six feet from the horizon, the disturbance of the image was a trifle greater than when the horizon was at the bottom of the excavation.

7. The horizon was set on top of the stone wall surrounding the excavation, and the pebbles were dropped *on the wall* at a distance of six feet from the mercury. The tremors were much stronger than before.

8. Two pieces of iron, weighing respectively one and two pounds, were dropped from different heights at various distances from the mercury; the weights were dropped, in each case, at such distances that the vibrations caused were barely perceptible. A discussion of these revealed the following law:

The intensity of vibration varies directly as the potential energy of the suspended weight, and inversely as the square of the distance between the mercury and the point of striking of the weight.

These observations seem to show that greater gain is to be expected from placing the piers of instruments at a distance from disturbing influences than from sinking their foundations deep in the earth. They are somewhat at variance with the first page of Loomis's Practical Astronomy.—*Sidereal Messenger.*

* Director of the Chamberlin Observatory, University of Denver, Colorado.

FENCE WALL GEOLOGY.

By Aug. F. Foerste.

In drift-covered areas actual exposures of bed rocks are often insufficient in number to determine even the simpler problems of geology. In such cases any assistance derived from other sources is often of value. In regions where the drift near its surface contains bowlders sufficient in size and abundance for the construction of fence walls, these bowlders will often furnish the desired data. Since such bowlders are placed in fence walls as a rule in the most expeditious manner consistent with the clearing of the adjoining fields, they have usually been removed too short a distance from their position in the fields to seriously affect any investigation as to their distribution. Moreover, an examination of the neighboring topography, the slope of the lands, the presence of streams and ponds, and similar data, will frequently even make their original position in the fields quite certain. The existence of fence walls also implies the existence of bowlders in sufficient numbers and of sufficient size to insure the observer that their original location, while a part of the bed rock, is not too far distant to make a study of their distribution profitable. The study of fence walls, therefore, becomes the study of the larger elements of the drift.

It is well known that near their source in the bed rocks the elements of the glacial drift are quite angular, but that owing to attrition the corners and edges are gradually blunted or worn off as their distance from the source increases, until finally the fragments become quite decidedly rounded. All this is of course accompanied by decrease in size. With a further increase of the distance from the original source the size of the bowlders becomes too small even for use in fence walls, and the further increase of distance is therefore also noticed by the smaller percentage of such bowlders *found* in the fence walls. This smaller percentage may also be due to another cause. For while the greater percentage of bowlders travel along the path of the glacier (or with its gradient) a considerable percentage deviate from this course; many 5, some 10, and a few as much as 15 degrees, thus affecting the percentage of such bowlders in the fence walls. Knowing the direction in which the glacial drift moved from the scratches it left on actual exposures of bed rocks, it is possible by means of an examination of the relative degree of angularity and size of rocks, the frequency of their occurrence in the fence wall, and a study of their distribution, to trace bowlders back to their original source.

It is evident that the study of very angular bowlders is alone of direct value in determining the original position of any class of rocks, since these alone lie near their original source. A record of the remaining bowlders of the fence walls is, however, of value in determining their probable distance from the original source, and in guiding future search. When bowlders are derived from rocks maintaining their lithological and paleontological characters over wide areas, the angular bowlders derived from one locality within this area will be mingled with the more or less rounded bowlders from some other locality in the same area, so that careful records are always of value in reaching accurate conclusions. Note taking is chiefly confined to recording the varying percentage of the various rocks forming fence walls and their degree of angularity. A record of their size, in addition to that usually already indirectly expressed in a record of their percentage, is usually of less importance.

The distribution of the very angular rocks will determine the form of the original area, whether the exposure was local and limited in all directions, formed a long narrow band, or covered a wide and extensive area. It will be of some assistance in this work to remember that the limits of any formation in going against the glacial gradient are near the line of more or less abrupt disappearance of all bowlders derived from that area, and that the limits of the same area on the side with the gradient are best determined by the similarly sudden appearance of bowlders of a *different* character. As the boundaries of any area approach parallelism with the glacial gradient, bowlders of nearly the same degree of angularity but derived from different sides of the boundary will become intermingled, so that in such cases the determination of the boundaries becomes more conjectural.

Studies based upon preceding principles having led to a rough delineation of the area formerly occupied by any class of rocks, it becomes necessary to correlate this area as determined by bowlders more closely with the area exposed by the bed rocks during erosion. For this purpose recourse is had chiefly to topographical features.

The most common of these are differences of elevation between two adjacent areas geologically distinct, due to the frequency with which rocks of different geological ages show different degrees of resistance to the action of erosion. This is likely to result in the formation of single hills when the original area was a boss of some igneous rock; long, narrow broken ridges or valleys when the original area was long and narrow, whether sedimentary or igneous in origin; flattened or much diversified areas of greater extent but of marked difference in general elevation when the original areas were of considerable extent. In such cases the boundaries between neighboring formations are apt to be found nearer the base of the hills or the top of the sides of the valleys expressive of the variable resistance offered to erosion by the different geological formations.

Any abrupt change in the character of a rock, from a sandstone to a conglomerate, a shaly series, an igneous formation, and the like, is a potential line of weakness. Owing to a variable degree of hardness and tenacity the rocks along such planes are apt to become separated during folding, and a moderate amount of sliding or faulting may take place on these planes, and give rise to additional fractures along the plane of

separation. The difference of velocity with which rocks immediately on either side of such planes transmit earthquake shocks is also likely to find its expression in a general loosening of the strata along those planes, accompanied often by some sliding. Ordinary faults in addition to a general plane of separation are often accompanied by minor fractures in the vicinity, owing to friction during faulting. All of such fractures, in whatever way caused, are liable to intensify the differences of elevation at the boundaries of adjacent geological areas, by offering regions favorable for the cutting action of erosion, whether by ice or water; and such fractures usually express themselves as beds of streams, long lakes, or valleys. In localities presenting great geological diversity and subjected to long erosion it is often found that the existence of a well marked valley, stream, or pond immediately heralds some change of formation which will be found on crossing the same. Boundaries of geological areas as determined by bowlders are then readjusted also with reference to neighboring streams and valleys.

Where the rocks dip toward their boundaries, the boundary streams will usually be found to remain near the fractures which determined their course. Where they dip away from their boundaries, especially if composed of softer rocks, the streams will often wander a small distance from their original beds. As a general rule the dip of rocks in the more recent formations is away from, in the older rock toward, any area of massive igneous rocks penetrating the same. This simply means that since such igneous rocks do not always show themselves at once at the surface, the element of time must be taken into consideration, and as a rule the anticlinals of any area are sufficiently eroded to expose igneous rocks not originally shown at the surface, before synclinals containing corresponding igneous rocks in the same position are sufficiently eroded to expose them. A certain allowance must be made for the probable change of course of any stream since its first connection with a series of fractures.

Such, in general, are the methods used in gaining some slight assistance from the bowlders of fence walls and from topographical features when the drift is too heavy to permit the frequent exposure of the bed rocks. Frequent modifications of these methods are used in the field, but the principles are all those well understood by the glacial geologist, and do not need further discussion. The amount of information often obtained in this way would no doubt be a matter of great surprise to those geologists who neglect all features except surface exposures. Yet, since the value of all such work is dependent upon the accuracy and distinctness with which the original boundaries of bed rocks, now drift-covered, can be traced, such methods find their best practical application where the dip of rocks is strong enough to furnish sharp boundaries along their strike (30° to 90°) where the structure is complicated, but not upon a small scale. Actual exposures, though isolated, always furnish a check upon such work.—*American Geologist.*

AN ENGLISH SCIENTIST ADVISES US TO CLOSE ALL GAS WELLS—A GREAT CRASH EXPECTED.

Prof. F. Maxwell Lyte, F. C. S., in a recent communication to the *Chemical News*, says:

It is worthy of consideration what will be the effect on the strata from which the natural gas which serves as the principal combustible in many parts of the United States is derived, as soon as it has all been used and when it falls to the ordinary atmospheric pressure. This must assuredly take place sooner or later, and probably at no very distant period, considering how rapidly the gas is being squandered. In the calculations below, the data on which they are founded are as follows:

1. The average pressure at which the gas issues from the wells is said to be about 200 lb. to the square inch =28,000 lb. to the square foot.
2. An acre contains 43,560 square feet.
3. A square mile contains 640 acres.

From these may be calculated the supporting pressure by which the overlying strata must at present be upheld from below.

Unless I am mistaken, the gas would give a pressure which, for each square mile, would amount to no less than 358,436,571 tons, equivalent to the weight of a fair sized mountain; so that on its ceasing to issue, proving thereby that the supporting pressure was withdrawn, the superincumbent strata would necessarily tend to give way. While the gas was there at so great a pressure there must have been an enormous pressure upward, and when it disappeared this would probably be replaced by a still greater strain downward.

The strata are already unable to support their own weight even over a limited area; witness the serious depressions occurring in many places over abandoned coal mines, and the numerous subsidences which are continually taking place in the salt districts; and most of the natural gas has been obtained from similar formations to these. Supposing the gas to be derived from reservoirs of gaseous hydrocarbons which have been liquefied by pressure, these reservoirs must have an unknown depth and area.

If the area be small no danger need be apprehended, from the great depth at which they are situated; but if large, as is probably the case, we, or our children, may yet be called on to witness such a dire and frightful catastrophe as the world has never seen, which would dwarf into insignificance the most terrible earthquake that ever happened.

That the size of such reservoirs must be very considerable may be concluded from the persistency with which the gas is disengaged always at the same pressure, and from the constancy of its composition. If the strata were to give way, the accident would probably be sudden, unexpected, and extensive. Very possibly, then, the inhabitants of those towns who draw their supplies of natural gas from the ground below them may be unwittingly working their own destruction by the use of this combustible; and while reposing in a fancied security, they may be preparing for themselves an abyss ready to swallow them up with scarcely a moment's warning.

Let us hope that these fears are unfounded, for the calamity is one that is almost too terrible to be contemplated. If others more in a position to investigate the matter, after considering what I have said, should agree with me as to the probability or even the possibility of the truth of my previsions, better at once close all the gas wells, or any way those which could possibly endanger any town, while there is yet time, and revert to the use of coal, of which America possesses such abundant supplies, than run the chance of a disaster such as I here foreshadow.

CORAL REEFS AND CARBONATE OF LIME.

At a recent meeting of the Edinburgh Royal Society, Dr. John Murray discussed the question of the origin and nature of coral reefs and other carbonate of lime formations in recent seas. He first referred to experiments which have recently been made regarding secretion and solution of carbonate of lime. Carbonate of lime remains are found in great abundance at the sea bottom in shallow waters, but the amount steadily diminishes as the depth increases, until at 4,000 fathoms almost every trace has disappeared. This is due to solution, as the organisms slowly fall to the bottom. Everywhere within 500 fathoms of the surface the ocean teems with life. The Greely expedition was starving within ten feet of abundant food which might have been obtained by breaking a hole through the ice and using a shirt as a drag net. Dr. Murray then proceeded to discuss his theory of the formation of coral reefs, bringing forward, in reply to objections by Dana and others, some recently obtained facts regarding the existence of shallow regions in what is, on the whole, deep water. He showed that carbonate of lime is continually produced in great quantity in warm, tropical water by the action of sulphate of lime in solution on effete products. This explains the great growth of coral in tropical regions. The absence of coral on certain shores in tropical districts is explained by the uprise of cold water due to winds blowing offshore. His paper was illustrated by an elaborate series of lime light diagrams.

[Nature.]

A MECHANICAL ILLUSTRATION OF THE PROPAGATION OF A SOUND WAVE.

Having to prepare some lectures on sound, I wished if possible to illustrate, without any very complicated apparatus, the way in which a sound wave is propagated.

The following method suggested itself to me. As I have not met with the method while examining a large number of works on sound and wave motion, I venture to send a description of it to *Nature*, as it may perhaps be of use to some students of acoustics.

A row of pendulums of equal length, $a, b, c, \ldots l$ (Fig. 1) are suspended from a rod, A B; in order to

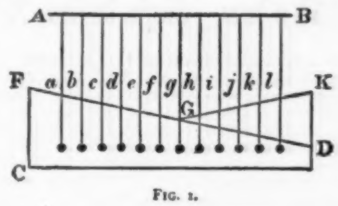


Fig. 1.

start the pendulums, the bobs are held against an angular shaped board, FCD, the rod being held in a plane slightly behind the plane of the board; if now the rod and pendulums be raised together vertically, l will first swing, then k, and so on, till all are free; when the pendulums are raised with a uniform velocity, then each pendulum starts at an equal period of time after the one which is next to it; the result is that a wave motion is seen to run along the line of bobs as they vibrate to and fro. Such an arrangement has been used to illustrate wave motion, as each bob moves with harmonic motion. But such an arrangement does not illustrate directly those compressions and rarefactions whereby sound is propagated. A slight movement, however, of the rod at once makes it do so. If, while the pendulums are vibrating, the rod from which they are suspended be turned in the horizontal plane through a right angle, the direction of the swing of each pendulum is not changed and all the pendulums swing in the same plane. This will become clear from Fig. 2, where the pendulum bobs viewed along

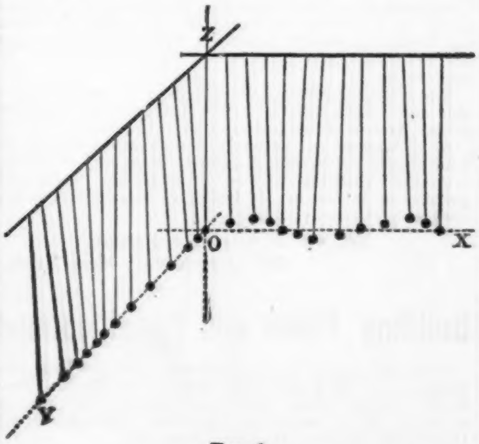


Fig. 2.

OX appear to trace out wave motion; the relative position of the bobs after the rod which supports them is turned through a right angle is shown along OY; the motion then illustrates mechanically those movements of air particles which, when in compression and rarefaction, propagate a sound wave. If the rod be turned back through a right angle, the wave motion is again restored. The illustration must be taken with the obvious defect, viz., that the bobs move in arcs, and not in straight lines.

Care should be taken that the amplitude of vibration be not greater than the distance between the points of suspension minus the diameter of a bob, otherwise the bobs will hit each other when vibrating in the plane, Y Z.

Twelve pendulums made of lead bullets 1·5 centimeter in diameter, suspended from threads 30 centimeters long, with a distance between each of 5 centimeters, were found to answer well by the author.

If the board used for starting the pendulums be made of the angular shape, FGK, then the movement of the bobs in their second position illustrates the propagation of sound on each side of its origin.

Frederick J. Smith.

Trinity College, Oxford, October 1.

FLUID EXTRACT OF ROASTED COFFEE.

Although the Pharmacopœia gives no formulæ for fluid extract of roasted coffee or for sirup of roasted coffee, I think the fluid extract and sirup are so frequently used at the present time as vehicles for quinine that it would be proper to have formulæ for these preparations in the next revision.

The National Formulary gives directions for both; 16 Troy oz. roasted coffee—No. 20 powder—are exhausted first with a menstruum of 4 fl. oz. of alcohol, 11 fl. oz. of water, 1 fl. oz. of glycerin, and then with a menstruum of 1 vol. of alcohol to 3 vols. of water.

I have prepared the fluid extract as directed here long before we had a National Formulary, and can say a good extract results. It makes a nice sirup, with a fine flavor and no sediment. The only disturbing element is the alcohol, which impairs both flavor and taste to some extent. To test its quality thoroughly I prepared a cup of coffee from it with hot water, milk, and sugar. The color was all right, but the taste didn't suit at all. It was evident that the alcohol was the disturbing cause.

I decided to prepare a fluid extract without alcohol. I proceeded as follows: I took 2 lb. av. of roasted coffee—about No. 30 powder—moistened thoroughly with 14 fl. oz. of boiling water containing twenty-five per cent. of glycerin. The moistened powder was packed moderately tight into a percolator—glass or earthenware percolators are best—and the same menstruum, boiling water containing twenty-five per cent. of glycerin, was used for exhaustion. Look out for your glass percolator when you use this menstruum. However, if the glass is of good quality and has become evenly warm from contact with the hot moistened powder, no break need occur. With a metal percolator no extra care is necessary. The very best percolator for this process is one with a jacket, in which the menstruum can be kept hot during the whole operation. But this is not indispensable. The first 28 vol. oz. of percolate are placed aside as finished extract, and percolation is continued until three percolates, each 2 vol. lb., numbered respectively 1, 2 and 3, are obtained, when the coffee should be practically exhausted. These three percolates are used successively for the next two lb. of coffee, and so on indefinitely or until you stop making the fluid extract. To prevent the reserve percolates 1, 2, and 3 from spoiling, I evaporate until only the glycerin containing the extractive matter is left. This is used in the next process in the same proportion as when pure glycerin is used.

Wishing to ascertain whether the ground coffee left in the percolator was really exhausted by the treatment as described, percolation was carried on after Nos. 1, 2 and 3 had been obtained, until one-half gallon more percolate had been secured. This was concentrated, precipitated with subacetate of lead, the lead precipitated by sulphureted hydrogen, filtered, filtrate rendered slightly acid and shaken with chloroform. The chloroform solution, upon evaporation, left a residue weighing one-half grain, showing that exhaustion was almost perfect.

I take pleasure in showing you a sample fluid extract prepared as described, in an ordinary percolator, without jacket attachment. The coffee used for this fluid extract is one-fourth Mocha and three-fourths Java, and the menstruum as already mentioned. This fluid extract makes an elegant sirup with a fine color and rich flavor, and keeps very well. I have kept some one year without becoming mouldy.

I have used fluid extract of coffee at the table for quite a time, and must say I am much pleased with it. I am never annoyed by coffee grounds, nor does it ever exhibit the bluish-gray color characteristic of coffee which has been in contact with metal a certain time, and to which milk is then added.—*G. H. Chas. Klie, Missouri Pharm. Assoc. Proceedings*, 1889.

SMOKELESS POWDERS.

Nothing is receiving more attention just now from offices of the army and navy than new powders. So far four European countries are known to possess a distinct nitrate powder. These countries are France, Germany, Italy, Belgium. All but the French powder are believed to be still in an experimental state, though it is difficult to learn anything definite from the government sources.

Dr. Griffiths, the renowned expert on powders, is the only living man outside of the official circles of the French government known to have had in his possession one of the new Lebel rifle cartridges. Dr. Griffiths was employed by the French government under an oath of secrecy to examine and give an opinion on the Lebel powder. All that he has publicly said is: "If all the Lebel powder is the same as that handed to me, it is certainly most excellent." Vague rumors have been circulated to the effect that the Lebel powder speedily deteriorates under certain climatic influences. Even this report cannot be confirmed or denied, but judging from Dr. Griffiths' opinion of the nitrate, it is fair to presume that the powder is serviceable.

The German powder is entirely distinct from the Lebel powder, but no report has yet been received that it gives to a projectile an initial velocity of over 2,100 feet per second, as does the Lebel powder. Of the Italian powder, the last report received says that the Italian government has ordered the immediate cessation of the manufacture of the new cartridges, serious defects in it having been discovered. As to the Belgian powder, nothing definite is known.

The French and Germans claim to have passed the experimental stage; Belgium lays claim to the same

honor. Austria and Russia are examining smokeless powders. Report has it that Russia will be provided with the Lebel powder in the event of allying herself with France on the outbreak of war with France and the "powers."

From England comes the story that when the Emperor of Austria saw the work with the German smokeless powder during the recent maneuvers he instantly exclaimed: "No such powder for me. None of it for Austria. If my troops use such powder they will no longer be enveloped with smoke. They will become exposed. None of it, I say, for Austria." But in a week the emperor changed his mind.

The only smokeless powder ever introduced into the United States is the Schultze sporting powder. Except for sporting purposes the Schultze powder has no especial advantages. The powder is the invention of a German army officer named Schultze, who sold out his rights to an English firm. The powder is white, and weighs about one-half as much as the best grade of black powder. In efficiency the Schultze powder is equal to the best grade of black powder. It is extremely clean and is nearly smokeless.

But as a rifle powder the Schultze is impracticable. It is very quick in burning, and this disqualifies it for use in rifles. The same objection applies to its use in heavy ordnance. To use a charge of 125 pounds of Schultze powder in one of the 8 inch rifles would in all liklihood burst the gun without affording any velocity to the projectile.

Dr. Griffiths is working on the Schultze powder with the object of adapting it to rifle use. The powder has been moistened so as to give it slowness in burning, and in that condition has given good results in rifles. But in very damp air it is found that the powder becomes still more moist, and again under the reverse condition it dries rapidly. The English, it is understood, have the first claim on the Schultze powder should Dr. Griffiths succeed in adapting it to rifle and ordnance use.

It is certain, however, that whatever the United States government does in the matter of obtaining a smokeless powder, it will never consent to buying it from foreign firms unless those firms agree to establish works in this country.

OPERATION UNDER HYPNOTISM.

By EDWARD L. WOOD, M.D., Resident Surgeon St. Barnabas Hospital, Minneapolis, Minn.

THROUGH the courtesy of Dr. Hugo Toll, of Minneapolis, Minn., I am enabled to relate the following case which, occurring in his private practice, still came under my personal observation, as the patient, at the time of operation, occupied a bed in our surgical ward.

A. S., male, aged seventeen, Scandinavian, entered hospital September 8, with osteo-myelitis in the upper third of the humerus. There was considerable pain and swelling, some redness, partial immobility of shoulder and elbow joints, and three fistular openings, one directly in the axilla, one slightly above the insertion of the deltoid, and the third higher up the arm and more posteriorly situated than the last one. In the three days preceding the operation the patient was hypnotized six times by Dr. Toll, in order to get him under good control. On the morning of September 9 he was hypnotized in his bed, and then led to the operating room and caused to lie upon the table. The several fistulæ were then explored, scraped out, and washed out, after which an incision four inches long was made on the outer aspect of the upper third of the arm, to the bone, and an opening three inches long and three-fourths of an inch wide chiseled to the medullary canal with considerable difficulty on account of the osteosclerosis.

I do not intend to give the technique of the operation, nor the clinical history of the case. The work was done under thorough antiseptic precautions. One fistula connected with the incision, and into the other two drainage tubes were inserted, the recent wound packed with iodoform gauze, and dressings applied with great ease, as the patient, while still cataleptic, could turn from side to side, move about, or sit up as we directed him.

At 9:50 A.M. he was led to his bed, and told that at twelve o'clock he could sit up and have something to eat, the nurses meanwhile being cautioned not to disturb him.

He lay perfectly quiet until that time, and at twelve o'clock sharp sat up in bed, stretched his well arm, and said, "Dr. Toll said I could have something to eat at twelve o'clock."

Amputation above the elbow would certainly not have been more painful than this operation, yet the hypnotic condition was preserved through it all, with a loss to the operator of not more than a minute and a half, all told. I have seen several minor operations done with the patient in a cataleptic condition, but to me this case was a revelation, as I think it will be to many of my fellow practitioners, throwing as it does a little light upon what it is possible to do with a favorable subject.—*Medical Record.*

TREATMENT OF SPRAINS.

IT may be observed that a sprain is frequently treated with a liniment advised by physicians. It is, indeed, painful to see a physician writing a prescription for a sprain. There are but two indications in the treatment of this affliction. First, to provoke rapid absorption of the fluid effused around and within the pain; and second, to favor cicatrization of the torn parts by immobilizing the articulation. Now, the modes of treatment in vogue do not fulfill these two indications. Massage would seem to present some real advantages, but it can be of little service in severe sprains, and mild injuries would probably do as well under rest alone. An elastic bandage, the depressed parts being covered with a layer of cotton so as to prevent too great pressure over the bony prominences, and thereby causing sloughs, will meet the first indication, and by its use in procuring rest it would meet the second indication. This bandage acts like massage in promoting absorption, and also secures immobility of the joint. It is of equal service in sprains complicated with rupture at the points of insertion, whereas massage would be productive of harm in cases in which splinters of bone were torn away. The practice of relieving the mind of the patient by giving him something to do in the way of applying bad-smelling liniments is a pernicious one, and really shows an unprofessional or unscientific attendant.—*Journal of the American Medical Association.*

JABORANDI AND THE HAIR.

"SOME discussion has taken place as to the use of jaborandi in connection with the hair. The senior surgeon to the London Skin Hospital states that it is a valuable drug in the treatment of diseases of the hair; promotes the growth in certain cases and influences the color in others. He deprecates its use, however, except under medical advice. The president of the British Trichological Association declares that jaborandi, when used with care and discretion externally for certain hair diseases, is undoubtedly a very useful drug, and, in cases which have not submitted to other treatment, must prove beneficial in every respect. Dr. Gurney, of the Hair and Skin Hospital, speaks highly of the drug, both as an external and an internal remedy."—*British and Colonial Druggist.*

THE NATIVE EGYPTIAN AS A SUBJECT FOR SURGICAL OPERATION.

"THE native Egyptian is an extremely good subject for surgical operation. Clot Bey, the founder of modern medicine in Egypt, has it that 'it requires as much surgery to kill one Egyptian as seven Europeans. In the native hospitals, the man whose thigh has been amputated at two o'clock is sitting up and lively at six.' Shock is almost entirely unknown, and dread of an impending operation quite an exception. In explanation may be noted the resignation inculcated by their religion; the very small proportion of meat in and the total absence of alcohol from their diet; and in general their regular, abstemious, out-of-door life."—*Medical and Surgical Reporter.*

THE
Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.